AAIB Bulletin No: 2/2001 **Ref: EW/C2000/6/1** **Category: 1.3**

Aircraft Type and Registration:	Piper PA-34-220T, G-BMNT	
No & Type of Engines:	2 Continental Motors LTSIO-36O-KB piston engines	
Year of Manufacture:	1981	
Date & Time (UTC):	1 June 2000 at 1132 hours	
Location:	Rowley Mile Course, Newmarket, Suffolk	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 2
Injuries:	Crew - 1 (Fatal)	Passengers - 2 (Serious injury)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Commercial Pilot's Licence (Frozen ATPL)	
Commander's Age:	52 years	
Commander's Flying Experience:	1,525 hours (of which 60 were on type) Last 90 days – 44 hours Last 28 days – 28 hours	
Information Source:	AAIB Field Investigation	

History of the flight

The aircraft was flown by the pilot on the morning of the accident from Oxford Airport to the July Strip at Newmarket Racecourse where he was to pick up two passengers. The pilot had been in contact with Cambridge Air Traffic Control on his inbound flight until shortly before he landed. After landing the aircraft parked at the southern end of the 32 grass landing strip while the pilot waited for the passengers to arrive. The onward flight was planned to go to Southampton to enable the passengers to get to a race meeting at Goodwood Racecourse. The aircraft was on the ground for about 30 minutes before departing.

There are two courses at Newmarket divided by a ditch and a 25 foot high dyke, known locally as the 'Devil's Ditch'. Witnesses on the July Course west side of the dyke heard the aircraft engines running and looked up as the take off began. They saw the aircraft accelerating along the runway and described seeing it bumping and bouncing an unusual amount. One witness then saw dirt or dust thrown up under the right main wheel and a short time later the aircraft became airborne. The passengers reported

that there were several hops into the air followed by the nose pitching down, the last of which resulted in a hard impact with the ground and an associated loud noise. Ground marks found on the runway showed that the right propeller was striking the ground for a period of one fifth of a second during the latter stage of the take off.

The aircraft then became airborne and immediately started to turn to the right crossing low above the course railings running along the side of the strip. Smoke or vapour was seen to come from the right side of the aircraft which climbed only slightly before disappearing from view beyond the dyke. Witnesses on the Rowley Mile Course, on the east side of the dyke, heard the take off but could not see the aircraft until it was crossing the dyke. They saw it hit the dyke and then cartwheel onto the ground below where a severe fire broke out.

The passengers were in the two rear seats, facing forwards, and were able to escape through the rear baggage hatch which had come partially open in the impact. The pilot was seated in the left forward seat and was not able to escape from the aircraft. One of the passengers attempted to assist the pilot from outside the aircraft but was unable to do so because of the intense heat of the fire.

The 1120 hours weather report from Cambridge Airport, which lies 8 nm to the west of Newmarket, was; surface wind 210°/10 kt, direction varying between 190° and 260°, broken cloudbase at 1,200 feet, visibility 10 km. Witnesses at the accident site observed that the wind was blowing directly across the strip, from left to right, and described it as "moderate" or "strong".

Pilot experience

The pilot was flying on a freelance basis for a company carrying their passengers to and from race meetings. He had been engaged on such work for the previous two seasons and thus had extensive experience of this type of flying operation. He had flown from the July landing strip at Newmarket on many previous occasions, usually in a Cessna 303 aircraft. In this aircraft it was his normal practice to use 10° flap for take off on grass runways, a recommended setting by the manufacturer. As a result of the Cessna 303 being unavailable he had been flying G-BMNT for a few days, which included several visits to the July strip during the 4 days preceding the accident.

The pilot had recorded 60 hours of flying on Seneca aircraft. All of his earlier experience on the Seneca was of long cross country sectors of up to 7 hours duration, the last recorded being in Africa in 1992. On the 27 May 2000 he began a series of flights on G-BMNT, the first of which was a solo familiarisation flight of 20 minutes, the remainder were longer cross country routes. There was no record of the pilot ever having received any flying training on a Seneca aircraft, or of having practised

engine failure and shutdown procedures on type, nor was there any requirement for him to have done so. He held a Commercial Pilot's Licence but was not required to undergo a type test to conduct a private flight. The most recent occasion on which the pilot had recorded any practice of asymmetric flight procedures was on 17 June 1999 when he completed an instrument rating test.

The post mortem examination of the pilot did not reveal evidence of any factors which could have contributed to the accident.

Aircraft performance

It was not possible to determine the exact loading of the aircraft but an estimate of the load and fuel on board indicated that the take-off weight was between 3,850 and 4,300 lb (1,745 to 1,950 kg). The maximum certificated take-off weight was 4,407 lb (1,999 kg). Performance figures were calculated for the purpose of this investigation using a mid range weight of 4,000 lb (1,955 kg). Using the known positions of the occupants the centre of gravity position would have fallen in the middle of the allowable range.

The July landing strip had a grass surface of 3,000 feet (914 metres) length and 230 feet (70 metres) width. The grass was short and the surface was firm and reasonably level with a slight upslope on the first half of Runway 32. The manufacturer's performance graph gives an expected ground roll for the aircraft from a grass runway in the prevailing weather conditions of 1,390 feet (423 metres) with 0° flap, and 700 feet (213 metres) with 25° flap. The actual ground roll to the start of the propeller ground marks was 1,000 feet (300 metres).

The Pilot's Operating Handbook (POH) for the aircraft states that the flap setting for a normal take off is 0° with a recommended rotate speed of 79 kt. When the shortest possible ground roll and clearance over a 50 foot obstacle is required a 25° flap setting is recommended, using a rotate speed of 64 kt. Following on from this information the handbook contains the statement: "when a 25° flap setting is used on the take-off roll, an effort to hold the airplane on the runway too long may result in a 'wheel-barrowing' tendency. This should be avoided." There is no different recommended technique for a crosswind take off.

There are a number of factors which affect the climb performance of this type of aircraft. The data reproduced in the POH for single engine climb performance assumes that the gear and flaps are up, the propeller feathered and the best rate of climb speed of 92 kt maintained. If any one of these factors is not met there is a decrease in performance, the magnitude of which is not quoted. The single engine performance with all these conditions met should have given a rate of climb of 450 fpm. With the extra

drag of gear, flap and propeller, the aircraft in a banked attitude, and a lower airspeed it is likely that most if not all of this climb performance would have been eroded.

The original certification requirements to be met by the aircraft stipulated that the minimum propeller ground clearance in the normal takeoff attitude must be 7 inches. In addition there must be positive clearance between the propeller and the ground in the level take-off attitude with the critical tyre completely deflated and the corresponding landing gear strut bottomed.

Site investigation

The aircraft lay on a grass field some 45 metres to the east of the Devil's Ditch (245 metres to the right of the runway centreline), pointing roughly on the take-off heading. The right wing had almost completely detached and was lying on the ground inverted with the Main Landing Gear (MLG) leg in the locked condition pointing upwards. The left wing inboard section, engine nacelle and MLG were still in situ and the remains of the aircraft stood supported by the left MLG. The left outboard wing had almost completely burnt away and dropped to the ground, as had the left engine mounting structure.

Almost all the aircraft above floor level had been consumed by an intense fire apart from the extreme rear fuselage and empennage, which was intact. It was, however, possible to determine that, immediately after coming to rest, the left wing and engine were intact whilst the right wing was almost completely detached. The right engine had been detached during the initial ground impact and had been thrown some 12 metres beyond the main wreckage. Both propellers had also broken off at the first major ground impact, evidence of which was found about 15 metres from the Devil's Ditch embankment. This area also contained a large amount of debris from the nose of the aircraft, including the battery and the nose baggage compartment and door. The distance from the first major ground impact to the point where the main wreckage came to rest was 30 metres.

At the extreme top of the embankment, a relatively light scar in the earth was found to contain pieces of fibreglass wingtip and the green navigation and white strobe light glasses. On the runway itself, about 20 propeller slashes were clearly visible with an associated mainwheel tyre impression running through the middle of them. The mainwheel mark commenced at the start of the slashes and finished as they stopped. A distinct, but slightly fainter, impression obviously from the nosewheel tyre, could be discerned 1.7 metres to the left, again commencing and finishing almost precisely at the same time as the right mainwheel mark (see Figure 1, Appendix 1). There was no clear impression of the left mainwheel. All the latter marks started 300 metres from the runway threshold markings and were slightly to the right of the centreline.

Site investigation analysis

The ground marks and wreckage distribution suggest that the take-off run had been ostensibly normal until the right main and nose wheels and propeller struck the ground. The aircraft was travelling straight along, and effectively on, the centreline. The propeller slashes were clearly made by an engine under high power and when measured their pitch corresponded to a groundspeed of 79 kt assuming take-off propeller RPM of 2,800. The tyre marks suggested a firm-to-heavy touchdown almost simultaneously on the right mainwheel and nosewheel.

The aircraft then appeared to have lifted-off and arced round to the right in a right-wing-low attitude, gaining insufficient height to clear the embankment which was struck by the right wingtip. This strike was sufficient to yaw the aircraft rapidly to the right and pitch it into the ground in a steeply nose-down 'cartwheel' manoeuvre. This impact detached both propellers by breaking the engine crankshafts and severely damaged the fuselage nose and right wing. The aircraft continued rotating around its vertical axis through about 270° before coming to rest travelling sideways, this rotation flinging-off the right engine. An immediate and intense fire followed. The site investigation also showed that both MLG's had been down and locked, although the massive disruption to the nose area did not make this so obvious with respect to the nose landing gear. However, the presence of a clear and heavy imprint from the nosewheel tyre on the runway suggested that it could not have been made by a landing gear leg which had folded or collapsed. All three oleo legs were fully extended on the site but subsequent attempts to measure the gas pressure in each failed due to fire damage to the internal seals: each could be compressed by hand. It was considered, therefore unlikely that an oleo strut had collapsed during the take-off run and the ground marks made by the right main and nose wheels did not suggest they were made by a deflated tyre.

Description of the propeller mechanism (see Appendix 2)

The aircraft was fitted with McCauley three-bladed, fully-feathering, constant speed propellers. These employ engine oil, boosted by a pump in the governor, to apply hydraulic pressure to a piston in the propeller hub. Increasing pressure moves the piston aft towards the fine pitch position, opposing spring pressure and counterweight forces which attempt to drive the blades towards feather. The governor regulates the oil pressure so that it exactly opposes the counterweight and spring forces when the selected RPM is reached.

Referring to the diagram at Appendix 2, longitudinal motion of the piston and piston rod (items 22 and 32) is translated into rotational movement of the blades by three light alloy linkages (item 25) which connect the piston rod, immediately behind the piston, to the blade actuating pin bolted to the blade root

(item 34). At the piston end, the link is attached by a small gudgeon pin, itself retained by a circlip (items 26 and 27), whilst at the blade end the link slides onto the blade actuating pin without any form of retention. Phenolic bushes are used at both ends of the links.

The high centrifugal loads exerted by the blades when the engine is running are reacted by the blade retention bearings (item 37), but when the propeller is stationary, the blades are kept in position by a large circlip (item 43) outside the hub.

Off-site engineering investigation

Following removal of the wreckage to the AAIB hangar, a more detailed examination was conducted. The severe fire damage and degree of disruption, particularly to the forward cockpit area, rendered a complete inspection of the flying control systems very difficult. However, where it was possible to examine the unburnt steel and aluminium components, no evidence of pre-impact failure or disconnection were found. It was noted that both elevator and rudder trim actuators were in the neutral range and that the manual flap selector lever was in the first detent (10°). This latter setting was also confirmed by physical inspection of the flap position on the left wing.

The investigation tried to establish whether the propeller strikes on the runway had resulted in any damage to the right engine or propeller which may have contributed to a possible loss of directional control and/or loss of climb performance. Accordingly, both propellers and the right engine were strip-inspected at a major overhaul agency under AAIB supervision. Externally, both propellers seemed remarkably little damaged by the main impact, which comprised a heavy blow to the front of the pitch-change cylinder in both cases. Hence all six blades were essentially straight apart from the three from the right propeller which had the tips curled back over about 15 cm in each case (see Figure 2, Appendix 1). When strip-inspected however, both propellers had suffered damage to the pitch change mechanism. Two of the links had become completely detached from their blade actuating pins in the case of the left propeller and one from the right. All the associated phenolic bushes had suffered damage to a greater or lesser extent. The blade retaining circlips of all six blades had jumped-out of their grooves.

No other anomalies were observed in either propeller, although the integrity of the various seals could not be absolutely verified due to distortion in some cases.

The right engine itself was also in quite good condition and internally completely undamaged. Externally the crankshaft had failed at the propeller attachment flange and one magneto had broken off. The fuel injection system and fuel lines still held quantities of fuel and the turbocharger was

undamaged and free to turn. Since this engine had not suffered any fire damage, it was possible to see that it, and the remains of the cowling, were not unduly soaked in oil, suggesting that a massive pre-impact oil leak had not occurred. Both magnetos were function-tested and found to be serviceable.

Off-site examination and analysis

No pre-impact defects associated with the right engine were found which could account for a loss of power on the right side. Indeed, it is reportedly quite rare to encounter serious engine damage purely as a result of propeller tip strikes. The same is not true of the propeller itself where, quite apart from the obvious damage to the tips, striking the ground several times under full power imparts a strong twisting moment on the blades towards the fine pitch setting. This will obviously apply high loads to the pitch control links, which try to resist such motion. In addition, the overhaul agency advised that they commonly encounter displaced blade retaining circlips on propellers which have suffered tip strikes. These circlips would not normally be loaded when the engine is turning, they simply retain the assembly together when the propeller is stationary, but the fact that they can be displaced during a tip-strike indicates the high forces which are exerted on the blade during such an event. It should also be noted that most tip-strike damage seen by overhaul agencies has probably occurred at low engine power settings, during taxi or landing for example.

The strip inspection revealed similar damage to both the pitch links and circlips on both propellers but it was impossible to distinguish between damage caused during the major ground impact and the tip strikes on the right propeller. However, the propeller manufacturer has advised that they would expect pitch mechanism damage to occur with a high-power tip strike and thus it is likely that one blade from the right propeller became free of the pitch change link after the tip strikes on the runway. In these circumstances, the blade counterweights should ensure that it rotates to the fully-feathered position. Under these conditions, a severe loss of thrust will occur due to the drag of the feathered blade and fining-off of the other two in an attempt to retain the selected RPM.

It was reported that the pilot had experienced a problem with a landing gear locked green light on the preceding day. The exact nature of the problem could not be determined. No other technical anomalies were discovered which could have contributed to the accident.

Discussion

The aircraft was found with 10° flap selected and it is probable that this was used for the take off. The manufacturer does not supply any performance data or publish a recommended technique for this flap setting. For the Cessna 303 aircraft, with which the pilot was familiar, take off techniques differed from

the Seneca in some respects. The Cessna 303 Pilot's Operating Handbook included the following information; flap 0° or flap 10° are recommended for normal take off. Under a paragraph entitled 'Crosswind take off' the following technique is recommended: "With the ailerons partially deflected into wind, the airplane is accelerated to a speed higher than normal, and then pulled off abruptly." The witness descriptions of the aircraft becoming airborne and landing again in a nose down attitude suggest that the pilot was not trying, or not able, to lift the aircraft off the ground.

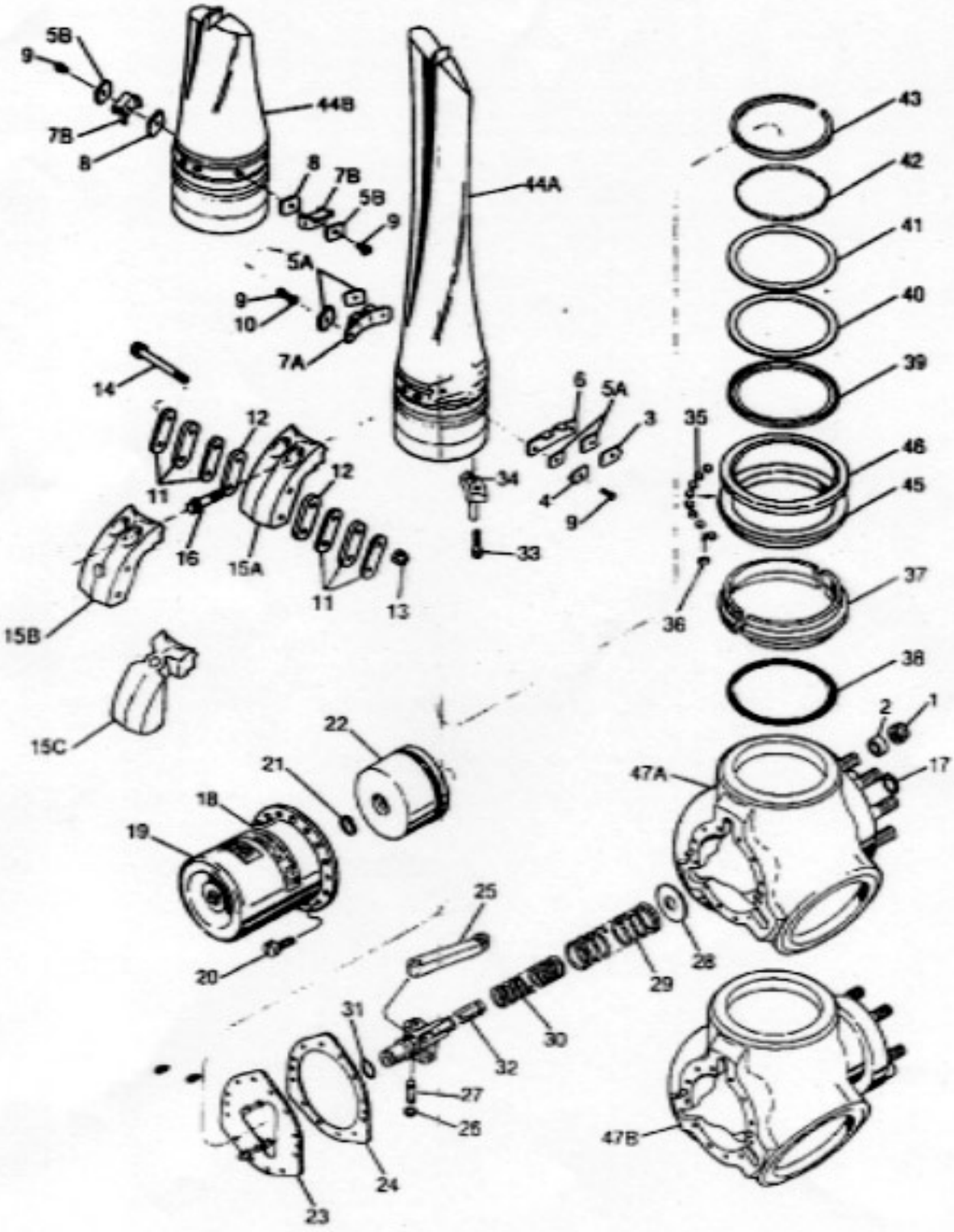
The ground propeller marks gave a computed groundspeed of 79 kt. To hold the aircraft on the ground at this speed would have required forward control inputs from the pilot and led to a tendency to "wheelbarrow" as described in the POH, or if it became airborne at any time would lead to porpoising. This undesirable condition would have resulted in a reduced propeller ground clearance. In a wings-level nose-down attitude it would be expected that both propellers would strike the ground together. For the right propeller alone to have hit the ground a right wing low attitude would be necessary. The heavy wheel marks from the nose and right gear and the absence of any mark from the left gear confirm this attitude. The significant crosswind from the left possibly contributed to the upwind wing lifting during the take off.

The remaining runway available at the time of the propeller strike was 2,000 feet (610 metres). The landing roll required from this point to a full stop would be 1,000 feet (305 metres). There was thus adequate runway remaining for the pilot to have abandoned the take off, or to have immediately relanded the aircraft and brought it to a stop, had he recognised the problem. The pilot would have heard the noise of the propeller ground contact but not necessarily have been able to identify the source. The right propeller rotated in an anti-clockwise direction viewed from behind and would throw any grass or dirt debris away from the aircraft and the pilot. It remains a possibility that he thought some other event, such as a landing gear problem, had occurred and this could account for his decision to continue the take off.

After lift off the aircraft was probably in a condition of a considerable degree of asymmetric thrust and drag. The fact that it continued turning to the right suggests that the pilot was unable to maintain directional control. The slight climb achieved is consistent with there having been some thrust contribution from the damaged right propeller.

Figure 1 - Photograph of wheel marks and propeller slashes looking in the take-off direction. Note impression of nosewheel tyre (arrowed)

Figure 2 - Photograph of right propeller as-found. Note curled tips to blades.



G-BMNT - Exploded view of propeller pitch-change mechanism, showing pitch change links (3 off) as item 25