

Cessna 152, G-BNGD

AAIB Bulletin No: 2/99 Ref: EW/C97/12/4 **Category: 1.3**

Aircraft Type and Registration: Cessna 152, G-BNGD

No & Type of Engines: 1 Lycoming O-235-L2C piston engine

Year of Manufacture: 1979

Date & Time (UTC): 21 December 1997 at 1637 hrs

Location: Near Ben John, Gatehouse of Fleet, Galloway

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: Commercial Pilot's Licence

Commander's Age: 44 years

Commander's Flying Experience: 1,222 hours (of which 773 were on type)
Last 90 days - 26 hours
Last 28 days - 5 hours

Information Source: AAIB Field Investigation

The aircraft had been leased by its owners to an Aero Club (AC) based at Carlisle Airport. In turn, it had been sub-leased to a Flying Group (FG) based at Prestwick Airport, who collected it on 17 September 1997. No defects were recorded following the flights on 17 September but, on 18 September, the pilot involved in this accident had indicated in the aircraft's Record of Flights that the aircraft's electrically powered Turn Co-ordinator instrument was unserviceable. In November 1997, the aircraft was ferried to Edinburgh Airport for a 50 hour maintenance check. The FG informed the engineering company of the Turn Co-ordinator's status. Following discussion between the maintainer and the AC the instrument was not replaced but was placarded as unserviceable. After its check on 7 November 1997, the aircraft was returned to Prestwick with the instrument still in this condition. The aircraft then flew some 19 hours until the time of the accident.

On 4 December 1997, the aircraft suffered a failure of the rudder bar at the left seat pilot's right pedal position, rendering it impossible to use the toe brake on that pedal. In order to effect a replacement, the aircraft was flown to Carlisle on 12 December, with a student pilot in the left seat and a licensed pilot in the right seat. Arrangements were made for a contract engineering company to effect the repair which was carried out by Friday 19 December.

The pilot involved in this accident was the Chief Flying Instructor (CFI) of the FG, this being a part-time post. He also had a full time weekday professional career outside aviation. He held a Commercial Pilot's Licence issued in June 1996, which also conferred the privileges of an Instrument Meteorological Conditions (IMC) Rating. The last recorded IMC Rating renewal flight test was on 24 October 1994. The pilot's Flying Instructor Rating permitted him to give instruction in instrument flying. The pilot's flying log book indicated that he had accumulated a total of some 50 hours of instrument flying experience, the most recent entry being 30 minutes instrument flying on 11 June 1997. Since that time, he had also given instrument flying instruction during 24 flights, including 5 flights in G-BNGD. He had conducted 5 flights at night in G-BNGD, the most recent being on 26 November 1997. The pilot's last recorded flight between Carlisle and Prestwick was on 14 September 1996.

The weather was unsuitable for the aircraft to be flown back to Prestwick on Saturday 20 December, the day after the rudder pedal repair had been completed, and the weather prognosis for the following few days after that weekend was not good. It was arranged that the CFI would go to Carlisle on Sunday 21 December in order to return the aircraft to Prestwick, as he wished to ensure that the aircraft would be available there for flying over the Christmas holiday period.

In addition, the FG wished to purchase an aircraft for their operation and arrangements had been made to view a potential purchase, a Piper PA-28 Archer. As this aircraft was based in the south west of England, arrangements were made to meet 'mid-way' at Caernarfon Airfield, North Wales on the morning of 21 December. In order to attend the meeting, the CFI was flown from Prestwick to Caernarfon by another FG member in a PA-28R Cherokee Arrow, registration G-WEND. The CFI inspected the potential purchase and carried out a demonstration flight from the right hand seat, with the aircraft's owner in the left seat.

At the conclusion of the meeting, the CFI reboarded G-WEND and was flown to Carlisle in order to collect G-BNGD. During this sector, both pilots discussed the weather conditions. The sector was flown at 3,000 feet and this was sufficient to be above the overcast cloud layer that covered the Lake District, but which broke up as the aircraft approached the Dean Cross VOR. Conditions were assessed as clear over the Solway Firth. Discussion also took place as to what course of action the CFI would take if poor weather/cloud conditions were to prevail over the direct route from Carlisle to Prestwick. He indicated that his alternative plan was to fly west along the north coast of the Solway Firth before turning north to track along one of the valleys towards the Ayrshire coast, or alternatively, to proceed along the coast as far west as Stranraer. (See Figure 1)

G-WEND landed at Carlisle at 1518 hrs. At that time, G-BNGD was still in the hangar. Arrangements were made to have the aircraft brought outside. It was agreed between the CFI and the pilot of G-WEND that they would both fly on a direct track from Carlisle to Prestwick. It was also arranged that the two pilots would communicate on a discrete VHF radio frequency during the flight. G-WEND (the faster cruising aircraft) departed first at 1538 hrs.

The pilot of G-WEND indicated that he encountered some poor weather (cloud and moderate turbulence) at 4,000 feet between Thornhill and Cumnock. After passing Cumnock, better weather conditions prevailed for the final part of its flight to Prestwick. G-WEND landed uneventfully at Prestwick at 1615 hrs.

G-BNGD was not refuelled prior to flight and calculations by the AAIB indicate that it probably had some 1.75 hours endurance available. The CFI called the Carlisle Tower controller for taxi clearance at 1540 hrs, getting airborne at 1548 hrs. Carlisle Airport was due to close at 1600 hrs and sunset occurred at about 1546 hrs. At 1552 hrs, the CFI advised Carlisle Tower that the aircraft was approaching Longtown and that he was changing frequency to Scottish Information on 119.875 MHz. There were no further transmissions between the aircraft and Carlisle. The CFI did remain in contact with G-WEND on the discrete frequency until about 1605 hrs and received weather status reports from that aircraft. By the time G-WEND was passing Cumnock, the CFI had indicated that his intention was to route at low level around the previously discussed coastal route.

At 1612 hrs, G-BNGD made contact with Scottish Information on frequency 119.875 MHz. At that time, the CFI reported that the aircraft was passing Burrow Head, estimating Prestwick at 1700 hrs and was flying at an altitude of 1,500 feet. The aircraft left this frequency between 1613 hrs and 1615 hrs in order to call West Freugh airfield for any traffic information, but West Freugh was not active at that time.

Just before 1627 hrs, the CFI indicated to Scottish Information that he could not maintain sight of the ground, so he was climbing to an altitude of 4,000 feet and tracking towards Turnberry VOR. When queried by ATC, the CFI reported that he had turned the corner passing West Freugh.

At 1629 hrs, the CFI reported that he thought that he had just had a suction pump failure. The aircraft was equipped with an air suction driven Attitude Indicator and Direction Indicator. In an attempt to assist the CFI with some radar guidance, the Scottish Information controller arranged for the aircraft to transfer to Prestwick Approach Control on 120.55 MHz, which was accomplished at 1631 hrs.

During his initial contact transmissions with Prestwick, the CFI stated that he was in Instrument Meteorological Conditions (IMC), that he was unsure of his position, that he had a suction pump failure and that he requested a radar advisory service. The aircraft was requested to set a transponder code of 7360 at 1632 hrs. A plot of the recorded radar data indicated that the aircraft was just to the south west of Barholm Hill (about 5 nm due east of the airfield at Wigtown) at that time. The CFI stated that he was at 3,700 feet altitude at that time.

The radar controller did not immediately identify the aircraft on radar and asked if it could climb to an altitude of 4,500 feet, which the CFI agreed to do, reporting that he was reaching this altitude at 1634:30 hrs. The controller was still having difficulty in locating the aircraft and requested the aircraft's last known position. The CFI responded that his last known position was about 20 miles south of Turnberry. He also commented that he was having difficulty holding a heading with the instrument failure.

The controller then located the aircraft and informed the CFI that he had intermittent radar contact about five miles east of Wigtown. At 1636 hrs, the controller passed the aircraft's position as being four miles east of Wigtown and 40 miles south southeast of Prestwick. The last transmission from the aircraft occurred just after 1636:30 hrs which was a partially unintelligible transmission containing the word 'descending'. Further attempts to contact the aircraft by the controller and by other aircraft passing close to the area were unsuccessful.

After an extensive search by the Police and Mountain Rescue Teams, the wreckage of the aircraft was located on high ground near Cairnharrow at about 0130 hrs the next day. The pilot had suffered immediately fatal impact injuries.

An aftercast from the Meteorological Office indicated that at the time of the accident there was a ridge of high pressure extending south westwards across England and Wales from a centre over Scandinavia with moist southerly airflow over Scotland. The weather in the area was misty with occasional drizzle and hill fog patches. The visibility was probably around 3,000 metres, reducing to 200 metres in cloud covering hills. The mean sea level pressure was 1012 mb. The cloud base was scattered to broken at 500 to 800 feet amsl, locally broken base 1,500 to 2,000 feet, with an overcast base between 3,500 feet and 4,500 feet. The freezing level was around 5,000 feet. The surface wind was from 130° at 5 kt, temperature +7°C, dew point +6°C. At 2,000 feet, the wind was from 190° at 20 kt. The southerly airflow was likely to have produced considerable lifting of the air mass over the high ground with the formation of quite extensive low cloud.

This was confirmed by eyewitnesses located just to the south of the accident site. They heard a light aircraft pass close by at the time that G-BNGD was in this vicinity and thought that the aircraft was circling. They confirmed that at that time it was dark, with cloud on the hills to the north of their location.

The recorded radar data from the Great Dun Fell radar site was plotted and overlaid on an Ordnance Survey map of the area. The first secondary radar return occurred at 1631:58 hrs. The aircraft appeared to conduct four or five left hand orbits with a northerly drift before radar contact was lost at 1636:16 hrs. The final plotted radar position was some 1,600 metres north of the accident site. From the derived speed of the aircraft and the measured radius of the turns, it was calculated that the aircraft would have had some 25 to 30° of bank applied during these orbits.

Accident site

The aircraft crashed in open hill country on the north side of the Solway Firth, 51 nm west of Carlisle Airport and 40 nm south-south-east of Prestwick Airport. Initial ground impact (Ordnance Survey Reference NX539548) was at a height of 880 feet amsl, on a saddle between two hills on the south-east side of Cairnharrow, a hill rising to a height of 1496 feet amsl. The terrain at the impact point was rocky, generally with overlying soil covered with heather, and sloped gently downwards towards the north-east. The initial impact area included substantial slabs of exposed rock.

Examination of the ground marks and the wreckage showed that the aircraft had struck in a steeply left wing down and nose down attitude at relatively high speed while heading 312°M. It suffered extensive break-up at initial impact and wreckage was distributed over an 80 metre long area extending down the hill, with the main remains coming to rest 56 metres north-east and 20 feet below the level of the initial impact point. There was no fire.

Attitude instrument description

The aircraft was fitted with three gyroscopic instruments, an Attitude Indicator (AI), a Direction Indicator (DI) and a Turn Co-ordinator. The AI provided indications of aircraft bank and pitch angles, the DI indicated aircraft heading, when synchronised with the compass, and the Turn Co-ordinator provided a combined indication of aircraft bank and yaw rates. The AI and DI were driven by a vacuum system that drew air across a gyro rotor turbine in each instrument, thus spinning the gyro. The system was powered by a carbon vane pump mounted on the engine accessory gearbox and driven from the accessory geartrain via a flexible coupling; the coupling formed the weak link in the drive train to the pump, ie the point in the drive train where failure was likely to occur in the event of overtorque. Maximum suction depression was controlled by a pressure regulating valve connected between the pump and the instruments and the depression achieved was indicated on a suction gauge, connected across the DI inlet and outlet (Figure 2.1).

The inlet air for both instruments was taken from a common vacuum system air inlet, fitted with a filter. The inlet filter and the regulating valve were mounted in the cockpit on the aft side of the engine bay rear bulkhead, somewhat forward and above the left rudder pedal assembly. The components were connected by flexible hoses fitted to a spigot at each connection point. Hose retention on the units fitted aft of the engine bay rear bulkhead was by means of a series of acute angled rings formed on the exterior of each spigot. For the connection between the regulating valve and the pump, each spigot had an enlarged diameter smooth ring formed near its outer end and the hose was retained by a steel spring clip fitted inboard of the ring. The spigots for this pipe run were steel and the hose was of 0.6 inch internal diameter.

The Turn Co-ordinator gyro was electrically driven. The instrument display included a red failure flag which was in view when electrical power was not supplied to the instrument.

Aircraft examination

The ground impact caused severe deformation and break-up of the aircraft, particularly of the left wing, the engine and the cockpit. Detailed assessment of a number of aspects of the wreckage was not considered relevant in the known circumstances of the accident. Evidence was found to indicate that no parts of the aircraft had detached before ground impact, that the engine had probably been turning at low power at impact, as suggested by the propeller damage characteristics, and detailed examination revealed no signs of pre-impact anomaly with the flight control system. Available evidence from the break-up characteristics and from cockpit instrumentation was consistent with a high rate descent at an airspeed in the order of 100 to 120 kt.

Positive assessment of the state of the AI, the DI or the Turn Co-ordinator was precluded by the severe break-up of the components. Most of the vacuum system components were identified, with the exception of the suction gauge, part of the inlet filter and a small end section of two hoses. Inspection showed that the vacuum pump had not suffered pre-impact internal break up, or failure of its drive train from the accessory gearbox. No signs of pre-impact failure of the regulating valve were found; the diaphragm was intact. Each of the hoses in the system aft of the engine bay rear bulkhead had either torn or become disconnected due to failure of its attaching spigot, consistent with the effect of impact damage and the available evidence, while not conclusive, suggested that these hoses had probably been intact and connected prior to impact.

The hose between the pump and the regulating valve had generally escaped damage and was intact, with both spring clips in place on the hose in their normal installed positions. At the pump end the rigid elbow to which the hose connected had been forcibly wrenched from its threaded socket in the aluminium pump body, the elbow remaining connected to the hose. However, at the other end, the hose was found detached from the regulating valve spigot, without appreciable damage to the hose or the relatively thin walled spigot. The evidence suggested that the hose may not have been fitted

on the spigot at the time of impact. However, given the type of connection, the possibility that the hose had been forcibly pulled from the spigot during the impact without causing damage to the hose or the spigot could not be dismissed.

No other pre-impact anomaly of possible relevance to the accident was found.

Maintenance background

Records indicated that G-BNGD had been imported from the USA in 1980 with a total of 1,780 operating hours and had subsequently been maintained under the CAA Light Aircraft Maintenance Schedule - Fixed Wing. After being leased to a series of operators the aircraft was leased to the AC at Carlisle and sub-leased to the FG at Prestwick. At the time of the accident the aircraft had accumulated approximately 3,315 operating hours from new.

The last scheduled maintenance check, a 50 Hour Check, was carried out at a maintenance organisation at Edinburgh between 4 to 6 November 1997, approximately 19 operating hours before the accident. The engineer conducting the check was informed by the FG that the Turn Coordinator was not functioning, and he subsequently confirmed that this was so. He reported that during discussion with the AC, his offer to provide a replacement was declined. The instrument was left in place, placarded with an "Unserviceable" label on the face glass.

During the maintenance check the vacuum system regulating valve filter was found to be dirty and was replaced. Information from an experienced Cessna 152 maintainer indicated that it is difficult or sometimes impossible to replace the filter with the valve in situ because of the closeness of the filter housing to the engine bay rear bulkhead. The clearance differs between individual aircraft but it is commonly necessary to unscrew the regulating valve retaining nut to allow the valve to be moved away from the bulkhead (Figure 2.2). Occasionally it can also be necessary to partially or fully disconnect the hose from the regulating valve outlet spigot, depending on the amount that the nut needs to be backed off (Figure 2.3). Full co-operation was obtained from the maintenance organisation that had conducted G-BNGD's check but, in view of the variability between individual aircraft, it was not possible to ascertain the details of the procedure that had been used to replace G-BNGD's regulating valve filter, in particular whether the hose had been disconnected from the valve outlet. After the work on the system it was confirmed in the course of an engine ground run check that the suction system, the AI and the DI appeared to function normally.

The aircraft was collected from the maintenance organisation on 7 December 1997 to resume service with the FG. Approximately 17 operating hours (26 flights) after the 50 Hour Check one of the pedals of the left rudder assembly was found to have broken and the aircraft was flown to

Carlisle on 12 December 1997 for replacement of the left rudder bar assembly by a Licensed Aircraft Engineer. This was completed on 19 December 1997.

Engineering analysis

It was noted that the repair to the rudder bar assembly immediately preceding the accident flight had involved work in the left forward lower part of the cockpit and that this was in the same general area as many of the vacuum system components. The possibility that inadvertent disturbance of the vacuum system had occurred in the course of the repair work was considered. This could not be totally dismissed, given the available evidence, but examination of a similar aircraft suggested no likely reason for the repair to have interfered with the vacuum system and no signs were found to indicate that this had occurred.

The evidence suggested that pre-impact disconnection of the vacuum system hose from the regulating valve outlet fitting may have occurred, although the evidence was not conclusive. Had the hose been only partially engaged on the valve outlet spigot the resultant leakage would have been small and suction forces would have tended to retain the hose. In such a condition, it would have been possible for the vacuum system to have behaved normally for a period of operation but for the hose to have suddenly detached from the spigot during the accident flight, possibly due to inertial forces. This would have caused sudden complete loss of vacuum and run down of the AI and DI. It was also possible that the regulating valve outlet disconnection had resulted from impact effects, and the possibility that a defect elsewhere in the system had resulted in loss of suction pressure, but was not apparent because of the severe crash damage, could not be dismissed.

Operational analysis

The contributory factors to this accident were a combination of circumstances, many of which typically feature in accident scenarios and each of which, in isolation, would not have caused the accident.

The pilot had intended to return to Prestwick that evening. It was also intended that the aircraft should have been at Prestwick during the Christmas holiday in order to be available for use by members of the FG. The pilot was aware that the poor weather forecast would prevent the aircraft from being flown to Prestwick during the following days leading up to Christmas.

The programme of activities for the day of the accident ran somewhat later than had been initially envisaged so that the return from Carlisle to Prestwick would occur during the hours of darkness, instead of in daylight as originally planned. The weather conditions along the route precluded the conduct of the flight while remaining clear of cloud, although the visual assessment of the conditions in the Solway Firth area, undertaken about one hour earlier, did not indicate this.

The pilot had planned to route on a direct track from Carlisle to Prestwick, but on hearing of the ambient cloud conditions and turbulence reports from the preceding aircraft, he made the sensible decision to route around the coast at low level, thus demonstrating his wish to remain clear of cloud during the flight. Unfortunately, this route had not been pre-planned and the pilot had no reference to a flight log to record the aircraft's progress or to produce accurate estimated times for the turning points (a flight on a direct track from Carlisle to Prestwick would have taken about 40 minutes in the ambient conditions, whereas the coastal route, via Stranraer, would have taken just over 70 minutes).

When the first contact was made with Scottish Information at 1612 hrs, the pilot reported that he was passing Burrow Head (the headland on the east side of Luce Bay). This position is some 56 nm west of Carlisle Airport and the elapsed flight time was 24 minutes. Given the cruising speed of the aircraft and the ambient wind conditions, it was not possible that the aircraft could have travelled so far west in the elapsed time. It is therefore more likely that the aircraft was approaching Kirkcudbright and Wigtown Bay at that time.

By the time that the aircraft flew into cloud while routing along the coast, the pilot's options were limited. Carlisle Airport had closed at 1600 hrs so there was no possibility of returning to land there. The airfields at Wigtown and West Freugh were unlit and therefore not visible in the darkness. The closest alternative airports with lighted runways were the Isle of Man, Belfast or Prestwick. At 1627 hrs, the pilot therefore took the decision to climb the aircraft to a safe altitude, clear of the high ground to the north of him, and route direct to Turnberry VOR for Prestwick (the aircraft's radio equipment consisted of a single VHF communication transceiver, a single VOR navigation receiver and a radar transponder with no altitude encoding facility).

The pilot's request for radar assistance at 1629 hrs was in response to the suction pump failure and his realisation that he was unsure of his geographic position. The suction failure would have rendered the aircraft's Attitude Indicator and Direction Indicator unserviceable. However, these instruments are not equipped with failure indications (the suction system has a pressure gauge with a marked 'green normal operating range', located on the instrument panel in front of the pilot). The indications produced by these primary flight instruments during the period of gyro rundown from normal operating speed may have led them to display erroneous attitude and heading indications to the pilot. As the electrically powered Turn Co-ordinator had been unserviceable for some three months, the pilot was left with no gyro instrument attitude references, it was dark and the aircraft was in cloud. In this situation, sustained control of the aircraft's attitude would be virtually impossible.

Nevertheless, the pilot changed radio frequency to Prestwick Approach control and requested radar navigational assistance. The pilot managed to climb the aircraft to 4,500 feet, achieving that altitude at 1634 hrs. The flight conditions at 4,500 feet were not determined, but it is possible that the aircraft experienced some turbulence and icing as it was in close proximity to the freezing level. At 1636 hrs, the pilot transmitted a somewhat unintelligible message which contained the word 'descending', possibly in response to these conditions. During the period between 1631 hrs and 1636 hrs, radar recordings show that the aircraft was carrying out a series of left hand orbits, which corresponded with a calculated average bank angle approaching 30°.

There were no external visual references and no valid gyroscopic flight instrument attitude or heading references. Conflicting sensory perceptions as to the aircraft's attitude are likely in this situation. It is therefore most probable that the pilot became disorientated and that the aircraft entered a spiral dive from which it did not recover, impacting the ground (some 880 feet amsl) at high speed.

The combination of circumstances in this case led the pilot into a situation from which the chances of a successful recovery were remote.