AAIB Bulletin No: 8/95 **Ref: EW/C95/3/3** **Category: 1.2**

Aircraft Type and Registration:	North American Aviation T-6G Harvard, G-BHTH
No & Type of Engines:	1 Pratt & Whitney R1340-AN1 radial piston engine
Year of Manufacture:	1950
Date & Time (UTC):	13 March 1995 at 1630 hrs
Location:	Bourne Park Airstrip, near Andover, Hampshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - Fatal Passengers - Minor
Nature of Damage	Damage to fin, rear fuselage, outboard left wing, cockpit canopy, engine cowling and propeller
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	500 hours (of which 10 were on type) Last 90 days - 9 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

History of the flight

The airstrip at Bourne Park is orientated 10/28 and 540 metres long. At the time of the accident the threshold of Runway 10 was marked by a circular area of grass which had been rolled and cut shorter than the surrounding tufted meadow grass. The final approach path to this runway crossed a line of trees about 150 metres from the threshold but on significantly lower ground. The uphill slope of the runway at the threshold was about 4° but the gradient levelled off gradually over the first 150 metres beyond the threshold. Winter rain had softened the strip surface and the ground was particularly soft in the undershoot of Runway 10. The aircraft was owned by the strip operator who used the strip to sustain his aircraft maintenance business. The pilot was a friend of the aircraft owner who sometimes ferried customers' aircraft to and from the strip. On the day of the accident he and the aircraft owner together decided that the strip had dried out sufficiently for the Harvard's first flight since January. The pilot made three short flights, each with a passenger occupying the rear seat. The passengers were holders of Private Pilot's Licences who, although they were invited to handle the controls during the cruise portion of the flight, were not expected to perform any duties. Throughout the day the weather was fine with a light wind from the north east, no cloud and about 10 km visibility.

The first flight to Thruxton where the aircraft was refuelled was uneventful. On the second flight, the aircraft took off from Thruxton and, after a short local flight, then returned to Bourne Park. According to the passenger the final approach to Runway 10 was flown at a normal glide angle at 90 mph (the correct speed). The approach also appeared normal to an observer who was standing by the side of the strip about 150 metres beyond the threshold. He perceived that before the aircraft reached the tree line, its steady glidepath would have resulted in a touchdown opposite him but, as the aircraft crossed the tree line, the pilot throttled back the engine and lowered the aircraft's nose. Just before touchdown near the threshold, the pilot used a small burst of power to cushion the touchdown on the uphill part of the strip. After touchdown the aircraft rolled along the strip and was able to turn around well before the end without any apparent need for harsh wheel braking. After taxiing in and shutting down the engine, the pilot was complemented on the excellence of his three-point landing.

After a break for tea and some minor adjustments to the aircraft's hydraulic system, the pilot and a different passenger boarded the aircraft for the third flight of the day. The passenger recalled that the pilot carried out normal checks before takeoff and they departed uneventfully at about 1600 hrs from Runway 28. In the cruise the passenger handled the controls and the pilot tested the operation of the flaps and gear which appeared to be working normally. On returning to the strip the pilot took control from the passenger and joined downwind for a left-hand circuit to Runway 10. Initially the passenger thought that the aircraft was slightly high on base leg but he based his judgement on the aspect of the strip. As the pilot turned onto finals, he reduced power significantly. When established on final approach, the passenger noted that the airspeed was stable at just below the 80 mph. Witnesses watching the approach thought that it was flown at a shallower angle and at a slower speed than for the previous landing. On nearing the trees in the undershoot, the aircraft began to sink slightly and the pilot added extra power to clear them. As the aircraft crossed over the tree line, engine power was reduced and the aircraft's nose was lowered to an angle the passenger described as steep. The witnesses also saw the aircraft's nose drop as it crossed over the trees, markedly increasing its rate of descent.

The passenger did not remember power being increased during the landing flare whereas other witnesses thought that power was increased in the flare, but not to full power, and there were no signs of a late go-around. Passenger and witnesses alike agreed that the aircraft touched down very heavily before the threshold and bounced slightly. After the bounce the aircraft remained tail high for a short time during which the propeller struck the ground several times. Soon after touchdown the chin of the aircraft's engine cowling dug into the soil and the aircraft somersaulted onto its back. The passenger was able to extricate himself without assistance but the pilot was less fortunate. The eyewitnesses ran the short distance to the aircraft and spoke to the pilot who was both conscious and lucid; he was struggling to free himself and asking for assistance to get him out but there was very little space

between the ground and the side of the fuselage. The aircraft owner went to fetch a tractor to lift the tail of the aircraft whilst other people attended to the pilot and passenger. After a short while the pilot stopped talking and became very still. The owner returned to the aircraft with the tractor but he was unable to lift the aircraft's tail with the tractor's lifting gear. A photograph of the accident site is shown at Figure 1.

Flight Characteristics

The approved Flight Manual for the Harvard stated that the final approach should be flown at 90 mph. The stalling speed in 1g level flight at the aircraft's estimated weight of 4,750 lb with gear and flaps down and power off should have been 57 mph. The descent angle from the trees to the first point of touchdown was approximately 6° and the ground there sloped upwards at 4.5°; consequently the landing flare required a change in flight path angle of 10.5°. A late flare could have raised the stalling speed by about 5 mph to 62 mph. The handling notes stated that touchdown should be made in a three-point attitude with the stick fully back at about 65 mph. There is no artificial stall warning in the Harvard; the warning comes from the aircraft 'feel'. The Flight Manual described the stall with the words: *"You can feel a normal stall approaching as the controls begin to loosen up and the airplane develops a sinking, "mushy" feeling. In addition, you can see the stalling attitude. When the stall occurs, there is a slight buffeting of the elevator and a vibration of the fuselage, and the nose or a wing drops."* The section of the manual which described the landing technique stated: *"Change attitude evenly and slowly; do not jerk the control stick or descend in steps. The attitude for a landing is similar to that attained in a gear and flaps down stall."*

Human factors

There was no record of the pilot ever having received formal tuition on handling the Harvard although he had occupied the rear seat during four flights when the aircraft was under the command of a qualified flying instructor experienced on type. At some time during those flights he had been the handling pilot for a takeoff and one or more landings at airfields other than Bourne Park. Notwithstanding the apparent lack of formal type conversion training, the pilot had studied the flight manual and his total experience on type as pilot in command was approximately six hours and eight landings. According to his flying logbook he had performed loops and rolls in the Harvard but there was no record of him having practised stalling in the type.

On 17 November 1994 a different pilot landed a Piper Lance at Bourne Park on Runway 10. This aircraft had touched down late and failed to stop before the end of the strip which was, at the time, bounded by a hedgerow. The aircraft ran broadside into the hedge incurring major damage. The

Harvard's pilot had been on board this aircraft assisting the pilot in command with the conduct of an airtest. Since that event, the Harvard pilot had landed at Bourne Park about eight times, mainly in Cessna, Grumman and Piper types. An engineer based there stated that since the earlier accident, he had noticed a tendency for the Harvard pilot to touch down very close to the runway threshold when ferrying aircraft into the strip. The landing roll distance for the Harvard on soft ground covered by short wet grass would have been about 330 metres which, in accordance with the CAA's Safety Sense Leaflet on aircraft performance, when factored by 1.43 to provide an ample safety margin, would have required a level strip length of 470 metres in zero wind conditions. The Bourne Park strip is 540 metres long.

History of the aircraft

The aircraft was imported into the United Kingdom in 1980 and certificated in the Private Category. In May 1991 it was damaged in a forced landing following an engine failure. The aircraft was then acquired by the present owner who repaired it and installed a new engine. In May 1994 the aircraft received a Certificate of Airworthiness in the Transport Category (Passenger). The maintenance records indicated that the most recent maintenance was a 62 day check on 10 February.

Accident site details

The ground marks indicated that the aircraft touched down heavily in the undershoot area where there was an uphill slope of 4.5°. The disposition of the marks showed that contact was made initially by the tailwheel, followed respectively by the right and left mainwheels. The right wheel made an impression in excess of one foot deep, which was sufficient to submerge it as far as the axle. It was apparent that the aircraft then bounced (although light contact was maintained by the left wheel) for approximately 6 metres, when propeller chop marks were observed in the ground. The mainwheel marks at this point were relatively shallow, and had torn the turf in a manner which suggested that the wheels were skidding as a result of brake application. The distance between successive propeller blade strikes progressively lengthened as the engine RPM reduced, and there was a large scar made by the lower part of the engine cowling before the aircraft nosed over onto its back. The aircraft came to rest approximately 70 metres from the initial impact point.

The line of trees before the runway threshold included three which were of significant height. The angle of a line drawn from the top of the tallest tree to the tailwheel mark subtended an angle of 6.2° to the horizontal, which therefore gave the minimum flight path angle.

Within the groundmarks it was possible to discern the wheel spin-up marks from the preceding touchdown. These were approximately 40 metres beyond the accident flight touchdown point, and within the mown area, although there was still an appreciable up-slope at this point.

Examination of the aircraft

The aircraft had remained substantially intact, with most of the structural damage being confined to the fin and rudder. The latter had broken off its hinge mounts and compression damage to the fuselage at the base of the fin had resulted in fouling of a bellcrank in the elevator controls. Otherwise the flying controls were found to be intact and functionable. The hydraulically operated flaps were found in the landing position, and the rudder, aileron and elevator trim controls were all at their neutral positions.

The wheels were free to rotate, which suggested that the braking action observed from the wheel tracks were the result of the pilot applying the brakes.

A small fuel leak was observed which emanated from one of the sight gauges on the floor of the cockpit. This ceased when the aircraft was recovered to the upright attitude. Fortunately there was no fire. This was largely due to the successful operation of a mercury switch, the purpose of which was to disconnect the battery under negative 'g' conditions. The master switch was found in the OFF position: it was likely that the pilot was responsible for this, as no-one involved in the immediate aftermath of the accident recalled touching this switch. However the fuel selector was turned off shortly after the accident. The battery terminal was also physically disconnected at about the same time but when the electrics were reinstated following the recovery of the aircraft, thick smoke billowed from an electrical loom behind the front instrument panel. The battery was disconnected once more, and the problem was traced to an ammeter wire shorting onto a deformed piece of structure. There was thus a strong probability that this could have initiated a fire following the accident but for the mercury switch.

The pitot system was checked using a calibrated test set, and the airspeed indicators in both cockpits were found to be accurate to within approximately 1 mph.

An external inspection of the engine revealed no visible damage and it was decided that it was capable of being run. Accordingly, the damaged propeller was removed from the engine and was replaced with an intact unit. The engine started and ran normally, and demonstrated immediate responses to throttle movement; the RPM lever was also exercised. The maximum RPM of this engine is 2,750; however the test run was limited to 2,000 RPM to guard against the consequences of any damage that may have been sustained by the supercharger during the accident.

Survivability

The emergency services arrived soon after the accident but the pilot died before they reached him. Air bags to lift the aircraft's tail and a harness cutter were used to free him. Although he was nearly six foot tall, the pilot habitually flew the Harvard with the seat pan fully raised. After the aircraft overturned, he was held in his seat by the four-point harness. The roll-over protection bar behind his

head had sunk into the soil surface by about 12 inches and much of his weight was taken by his shoulders. His head was flexed forward and the weight of his legs was taken by the base of the instrument panel but their upward movement relative to his torso would have added to his discomfort. A post-mortem examination revealed that he died from traumatic asphyxia; his other injuries were very minor. The passenger suffered only minor injuries, mostly of a muscular nature.

The seat harnesses were of the four-point type comprising a lap strap and two shoulder straps which were attached to a spring loaded reel mounted on the rear of the seat. The reel could be locked by means of a lever mounted on the left side of the seat. The lap strap webbing was stiff and appeared to be original; however the shoulder straps seemed to be of more recent manufacture. None of the components bore any manufacturer's identification marks. Eyes in lugs attached to the shoulder straps are passed over a hasp on one of the lap straps which engages with a hook and locking lever assembly on the other lap strap. It was noted that when the lap strap assembly was adjusted so that it was loose, the shoulder straps pulled on each lap strap half so that they formed an inverted 'V'. This altered the geometry of the hasp in the hook such that releasing the harness, by means of operating the locking lever, became difficult and sometimes impossible to achieve. This feature was apparent on both front and rear harnesses. A photograph of the harness with the connector in the potentially jammed position is shown at Figure 2. Long term wear patterns could be discerned on the mating areas of the hooks and hasps with the lap strap in the inverted 'V' noted above. It could not be established whether the pilot had remained strapped in his seat through an inability to release the harness.

In order to understand more fully the predicament of the pilot with the seat in the inverted position, both seats were removed from the aircraft and taken to the Royal Air Force School of Aviation Medicine (RAF SAM) at Farnborough. The rear seat, on which the harness was still intact, was mounted on an invertible rig. Tests were conducted using initially a mannikin (ie a humanoid dummy), and later a person of similar height and build to the deceased pilot, installed on the seat.

The RAF SAM report noted the following:

"Traumatic asphyxia is not a common finding at post -mortem examination, and occurs primarily when there has been restricted movement of the chest wall which hinders the expansion of the lungs. This restriction can occur in situations which result in compression of the chest by external forces, and where the lungs and thoracic contents are compressed by upwards pressure on the diaphragm from abdominal organs. In this accident.....(the pilot) was inverted; the human body is intolerant of prolonged inverted hanging, particularly as blood can enter the head and neck from the high pressure arterial supply, but cannot freely exit via the low pressure valveless veins of the head and neck. Hence pressure in the skull increases and the blood flow to the brain stagnates, hastening the onset of unconsciousness and death from hypoxia."

The inversion tests using the mannikin involved flexing the torso forwards to reproduce the as-found position of the pilot. It was observed that the harness connector adopted the angle as described earlier such that its release was extremely difficult. The test was repeated using the human volunteer: with the rig inverted and the torso of the subject flexed forward, the overlap of the thighs onto the abdomen resulted in it being virtually impossible to reach and release the harness. The test had to be abandoned after a few minutes due to distress experienced by the subject.

The final part of the assessment was simply to position the subject horizontally on the floor with the legs brought up onto the chest. This simulated the pilot's feet "falling" away from the rudder pedals in the inverted attitude, but without the contribution of any interaction with the harness. In this position the abdominal contents are pushed up into the chest and, once again, the subject felt uncomfortable and experienced breathing difficulties.

The report concluded by saying that, for a person with the body build of the pilot, the compression of the chest caused by the flexed forward torso, plus the effects of the legs being brought up onto the chest, it would be possible for severe respiratory embarrassment to occur in the inverted position.

In view of the demonstrated problems with the seat harnesses as fitted to this particular aircraft, the following recommendation has been made to the Civil Aviation Authority:

Safety Recommendation 95-10

It is recommended that the Civil Aviation Authority publicise, for example, by means of an article in GASIL, the potential difficulties of releasing this type of harness if the aircraft is inverted, and emphasising the importance of correct adjustment of the harness.

Figure 1. View of accident site

Figure 2. View of harness with buckle in potentially jammed position
(Photo: RAF School of Aviation Medicine)