Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Bell 206A Jet Ranger G-AXAY
Report on the accident at Inkpen Hill, near Hungerford, Berkshire, on 7 March 1974

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Department of Trade
Accidents Investigation Branch
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18 April 1975

The Rt Honourable Peter Shore MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr P J Bardon, an Inspector of Accidents, on the circumstances of the accident to Bell 206A Jet Ranger G-AXAY which occurred at Inkpen Hill, near Hungerford, Berkshire on 7 March 1974.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 6/75
(EW/C478)

Aircraft:	Bell 206A Jet Ranger G-AXAY
Engine:	One Allison 250 C-18B
Registered Owner:	Camlet Helicopters Ltd
Operator:	Air Sea Helicopters
Crew:	Pilot (One) - Killed
Passengers:	One - Killed
Place of Accident:	Inkpen Hill, near Hungerford, Berkshire
Date and Time:	7 March 1974 at 0940 hrs
	All times in this report are GMT

Summary

The helicopter was on a charter flight from Titchfield near Fareham, Hants to South Marston near Swindon. As it passed over Inkpen Hill, near Hungerford, on track and in good weather, the main rotor became completely detached, striking the nose section of the aircraft as it did so. The aircraft struck the ground in a near vertical attitude and caught fire. Both occupants of the aircraft were killed. It has not been possible to establish the cause of the accident.

1. Investigation

1.1 History of the flight

The helicopter, which was on charter to the Plessey Company, had left its main base at Stapleford Tawney at 0830 hrs on the day of the accident and had flown to Titchfield, near Fareham in Hampshire, where it landed at 0918 hrs. The engine was kept running whilst two of the three passengers disembarked and approximately two minutes later the aircraft took off again for South Marston. The sole remaining passenger was seated directly behind the pilot in the rear right hand seat.

It was apparently the pilot's intention to make the flight under visual flight rules, and to fly to the east of the direct track so as to avoid the Bournemouth Control Zone and the Andover Military Air Traffic Zone.

Nothing was heard from the aircraft after it left Titchfield but at approximately 0940 hrs it was seen flying normally in a north westerly direction at betwen 300 - 500 feet above the ground as it approached Inkpen Hill near Hungerford. Shortly before reaching the brow of the hill, a series of unusual noises was heard to come from the aircraft. These were described by witnesses as a coughing sound followed by a bang and then a roar. It was subsequently established that these noises were associated with the main rotor becoming completely detached and its blades striking the front end of the fuselage. At the same time the pilot was ejected from the aircraft with considerable force. His body was later found 126 metres further on and to the left of the aircraft's track. After the main rotor became detached, the aircraft continued on for a short distance, descending and turning rapidly as it did so. It struck the ground in a near vertical attitude on the brow of the hill, disintegrated and caught fire. The passenger was killed on impact.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal	1	1	–
Non-fatal	–	–	–
None	–	–	

1.3 Damage to aircraft

The aircraft was destroyed

1.4 Other damage

None

1.5 Crew information - the pilot

(a) Age: 48 years.

Licence: Airline Transport Pilot's (Helicopters) Licence, valid until 28 January 1975.

Aircraft Ratings: Group 1, Bell 206A, Westland S55 series 3.

(b)	Engine:	Allison Model 250 - C18 B.
	Date of Manufacture:	October 1969.
	Total running time since new:	1,196 hours.
	since overhaul:	432 hours.
	since last check 1:	32 hours.
	Type of fuel:	JP1A (Aviation kerosene).

1.7 Meteorological information

According to all eye-witness accounts the weather in the vicinity of the accident was fine, with no low cloud or precipitation, and good visibility. Although according to the Meteorological Office the general wind velocity in the area was approximately 100° 5 knots, evidence from the wreckage suggests that over that part of Inkpen Ridge a light southerly or south westerly drift must have prevailed.

The weather is not considered to have been a factor in this accident.

1.8 Aids to navigation

The evidence suggests that the pilot, who was familiar with the route, navigated by map-reading on the Titchfield - South Marston sector. A 1:250 000 scale topographical map was found in the wreckage. It had drawn on it a track of 036°(M) for the first 10 nautical miles from Titchfield followed by one of 332°(M) to South Marston. This route would avoid the Bournemouth and Andover Control Zones.

Both VHF navigation receivers were selected to Midhurst VOR (114.0 MHz). Although probably the most suitable navigational aid available, this VOR station would not have been of great assistance owing to its location a considerable distance to the east of the intended track.

The ADF receiver was tuned to 910 kHz, BBC radio 4. It is probable that in view of the comparatively fine weather and his familiarity with the route the pilot had made the reasonable assumption that he need not use this receiver as a navigational aid.

1.9 Communications

Communications between the aircraft and ground stations between Stapleford Tawney and Titchfield were apparently normal. The pilot did not call the company radio station at Titchfield, either on arrival or departure, nor was he required to do so. Thereafter no further communication was heard from the aircraft. However, both VHF sets were found switched ON and selected to 125.35 MHz which is the frequency of Boscombe Down, the controlling aerodrome for the Andover Air Traffic Zone.

1.10 Aerodrome and ground facilities

Not applicable.

1.11 Flight recorder

Not required and not fitted.

1.12 Wreckage

The accident happened over mainly open country and the ground in the immediate area where the rotor became detached was flat. The distribution of the wreckage is shown on the diagram at Appendix 1 and it should be noted that items 1-30 were released from the helicopter before impact. The first item on the wreckage trail was the main rotor itself. The geographical location of this item was on the intended track of the aircraft. However the trajectory of the fuselage after rotor detachment was some 40 degrees to the right of the course for South Marston, and it can only be concluded that as a result of the detachment of the rotor and the resulting forces to which the aircraft was subject, a change of direction occurred.

The scatter of the various components released from the helicopter before impact confirms that it was turning rapidly as it descended, resulting in each item being flung out by centrifugal force. The direction of rotation is thought likely to have been anti-clockwise as viewed from above.

An item of some significance was the pilot's brief case (item 8 on the diagram at Appendix I). This was found lodged in a tree at a height of 70 feet and to the right of the trajectory of the fuselage after rotor detachment. One end of the case had been cleanly severed and it is considered that this had been done by one of the main rotor blades.

A detailed examination of the wreckage established the following:

(1) The rotor mast had fractured 6 inches from its splined end immediately below the rotor stops. It was apparent that the fracture occurred after the mast had bent first in one direction before failing in the reverse direction. The fracture was consistent with a ductile failure in the bending plane with no evidence of torsion, fatigue or material defect. The nature of the failure indicated that a rapid oscillation of the rotor had occurred. This was confirmed by an examination of the rotor static stops which could be seen to have sustained considerable damage caused by repeated strikes by the head of the mast. The stops themselves were found to be of a type (Part No. 206-010-187-1) normally used in conjunction with an unmodified type of mast (Part No. 206-010-332-1). As the mast fitted to this aircraft was of the modified type, (Part No. 206-010-332-13) stops to a later standard (Part No. 206-919-109-1) should also have been fitted. The effect of combining a modified mast with unmodified stops was to reduce the mean flapping angle from 8^{o} 18′ to 7^{o} 12′. However as the purpose of the stops is to restrict the rotor flapping angle during rotor run down on the ground, it is not considered that the fitting of the incorrect type was a factor in the accident. No evidence of pre-crash failure of the main rotor blades or of the main rotor hub assembly itself was found.

(2) The front end of the fuselage showed evidence of having been struck from underneath by the rotor blades in the area of the battery compartment. From witness marks on the battery tray, it could be seen that it had been struck from below by leading edge of a blade; the other parts of the fuselage nose had also been struck, but in this instance by the flat of a blade. From a study of the geometry of the helicopter, it was apparent that the rotor blade strikes had occurred after rotor detachment.

(3) The collective and cyclic control systems runs were extensively damaged by impact and fire damage and it was therefore not possible to prove their pre-crash integrity. However of the parts that were recovered, there was no indication of pre-crash failure. The collective and cyclic servo actuators were examined initially by X-ray and later by stripping. In the left hand cyclic servo actuator, it was found that the sequence valve plunger pin in the return line (Part No. 30000678) was bent over the poppet valve seat, thus preventing the

poppet valve from closing. The function of this valve is to close when in manual (ie hydraulic power OFF) operation. It also acts as a thermal relief valve. It was also found that the valve's preformed packing seal (Part No. MS 2775-008) was fractured.

(4) All damage to the power train system (ie the drives to the main and rail transmission gear boxes) was consistent with it having occurred as a result of impact forces. There was no evidence of pre-crash failure.

(5) The engine sustained considerable damage on impact and there was clear evidence that it was rotating at a high rpm at the time. There was no evidence on strip examination of any pre-crash defect or failure.

(6) Though the inverter was stationary on impact, the electrically driven gyros in the flight instruments which derive their power from the inverter were rotating at a high rpm. This indicates that the inverter had been functioning normally up to the moment of rotor detachment. Furthermore there was evidence that electrical power was available to at least one radio and that three lights were probably illuminated on impact, namely:

Transmission Oil Pressure Warning light
Panel light
One unidentified light

(7) Both VHF transceivers were selected ON and tuned to 125.35 MHz. Both VHF navigation receivers were selected ON and tuned to 114.0 MHz. The ADF receiver was ON and tuned to 910 kHz. Two headsets were found in the wreckage, one of which was still serviceable.

(8) The cockpit instrumentation and controls were extensively damaged. The hydraulic control switch was found to be out of its gated ON position, though not fully in the OFF position. Tests made subsequently showed that the switch could be pushed out of the ON position. The pre-crash position of this switch could not therefore be positively established.

(9) All the seats and lap straps had been destroyed by fire. Only three of the five metal strap fasteners were found, two of which were fastened.

1.13 Medical and pathological information

A full autopsy was carried out on the pilot and revealed no medical cause to account for or contribute to, the accident. Both occupants had died from severe multiple injuries. The pilot had sustained additional injuries consistent with his having been ejected backwards from the aircraft.

1.14 Fire

Fire broke out in the main section of the fuselage shortly after impact, largely destroying it. The first fire appliance arrived from Hungerford at 1007 hrs, approximately 27 minutes after the accident, and damped down the smouldering wreckage with water.

1.15 Survival aspects

The accident was not survivable. There was no indication that the pilot had been restrained by his seat belt, although it was his normal practice to use one. Evidence suggests that the seat belt attachment may have been released at the mounting point following impact of one of the rotor blades in that area.

1.16 Tests and research

1.16.1 *Flight tests*

The manufacturers of the helicopter were asked to evaluate the effect on the controllability of the aircraft of the bent sequence valve plunger pin in the left hand cyclic actuator. Extensive flight tests were conducted, during which the aircraft was flown firstly with a serviceable valve fitted and then with a bent valve fitted. No marked change in the handling characteristics of the aircraft was noticed when the bent valve was installed. Only when abnormally high rates of pitch or roll were demanded was there a noticeable reduction in response. Further tests were then conducted with the valve broken and some degradation in handling qualities was observed. It was also established that the broken seal in the valve assembly resulted in a very low leakage rate and the effect of this on the handling characteristics was negligible.

1.16.2 *Rig tests*

It was established during the investigation that the sequence valve could be readily bent during normal rig testing of the actuator when excessive hydraulic supply pressure was applied. It was learnt that this had occurred on a number of occasions in the past.

1.16.3 *Briefcase stowage*

Since it is known that the pilot habitually stowed his briefcase on top of the glare shield above the instrument panel, a test was made on the ground to check the consequences of the briefcase becoming dislodged. The glare shield is curved both laterally and on its forward face. When the briefcase was given a very slight push, it fell rapidly sideways and forwards coming to rest on the curved perspex panel in the nose and against the starboard rudder pedals. It would only be recovered with difficulty by someone sitting in the pilot's seat.

1.17 Other information

1.17.1 *Remedial action - Servo actuator valves*

Subsequent to the accident, the manufacturer has introduced a number of measures to prevent a recurrence of bending of the sequence valve plunger pin. This has involved a change of material specification of the poppet valve and guide, the plunger and packing seals. Also instructions have been issued to operators to test the sequence valve for leakage which would indicate a bent plunger pin. The United Kingdom Civil Aviation Authority has since endorsed these measures and classified them as mandatory for all UK registered helicopters of this type.

1.17.2 *Previous accidents to Bell 206A Helicopters*

A large proportion of the accidents to Bell 206 A and B helicopters was studied and it was found that there was no previously recorded instance of the rotor being detached in the same circumstances as those pertaining to the flight of G-AXAY. However an incident involving a loss of control was noted which may be of some significance. This occured when a pilot applied left rudder to correct for yaw. The aircraft immediately pitched up and rolled over until it became inverted. It then tumbled end over end, completely out of control. The pilot eventually regained control and landed without further incident. No explanation for the occurrence could be found.

2. Analysis and Conclusions

2.1 Analysis

The accident occurred when the rotor head became detached from the fuselage, but despite exhaustive tests, it has not been possible to establish any reason for this. The fracture of the rotor mast must have been associated with a severe oscillation such as would be produced by low rotor rpm, or a large and rapid input on the cyclic flying controls, either pilot induced or otherwise. Consideration was given to a number of possible ways that this might have occurred but none of them could be fully substantiated. These are as follows:

(1) Pilot incapacitation.

There was no evidence either from the pilot's medical history or from the results of the autopsy that pilot incapacitation was a factor.

(2) Cyclic Control Sequence Valve Plunger Pin.

The result of the tests carried out by the manufacturer established that the presence of the bent sequence valve plunger pin in the cyclic pitch control is unlikely to have contributed to the accident. Indeed, flight tests in an aircraft fitted with a bent plunger similar to that found in the accident aircraft showed a barely detectable change in control characteristics during normal control motions.

Even if taken in conjunction with some other malfunction, such as a loss of engine power, the contribution of the faulty valve to any possible control difficulties should have been minimal.

(3) Engine malfunction.

Although a total loss of power seems unlikely in view of the evidence that the engine was rotating at considerable speed at the time of impact, the possibility of its having lost power immediately prior to the mast separation cannot be ruled out. Supporting evidence was provided by witnesses who heard a coughing sound prior to the 'bang'. Although the majority of fuel system components were found to be serviceable, because of the accident damage it was not possible to check the entire system. Therefore the possibility of, for instance, temporary fuel starvation with subsequent loss of power, cannot be completely ruled out. However, faced with an emergency of this nature, and in the absence of any other complicating factors, there was no reason why the pilot should not have carried out a successful forced landing in autorotation.

Assuming a serious loss of power did occur, a period of some five seconds would have to elapse before the rotor rpm had decayed sufficiently to induce an oscillation of the rotor head. The only action required by the pilot during this time to correct the situation would have been to lower the collective pitch lever. However, there are a number of possible reasons why corrective action may may have been delayed, the most plausible being that the pilot's attention was distracted whilst trying to find the cause of the engine malfunction. It would seem unlikely however that an experienced helicopter pilot would allow this to occur. He would have practised the engine failure procedure many times, and his reaction should have been almost automatic and instantaneous. The possibility cannot be ruled out that downward movement of the collective pitch

lever was prevented by some obstruction. However, there was no evidence to substantiate this theory.

(4) Negative 'g' rotor blade loading.

It is a known characteristic of certain types of helicopter that should they be subjected to a push-over manoeuvre, so that the loading on the rotor gradually decreases, control power will slowly decay, becoming zero at zero 'g'. If the blade loading becomes negative, there is a reversal in cyclic pitch control. Thus should a helicopter of the teetering rotor type be subjected to negative 'g' for any appreciable length of time, control would almost certainly be lost and during the process the rotor blades could well oscillate. However, in the case of G-AXAY, there were no reports of erratic behaviour prior to rotor detachment such as would have been apparent had control of the helicopter been lost. Nor is it likely that an experienced helicopter pilot would deliberately apply negative 'g', unless perhaps to take sudden avoiding action, for instance from the path of a large bird. There is no limitation or warning in the flight manual for this type of helicopter regarding the avoidance of flight at less than 1g.

(5) The pilot's briefcase.

The possibility must be considered that the briefcase, which was known to have been on the glare shield in front of the pilot, may have fallen rearwards (ie towards the pilot), and during its fall struck the cyclic control lever. However, the pilot would normally have been flying with his hand on the lever, and it would seem unlikely that he would have been caught completely unawares. Even if this had occurred it is difficult to believe that the cyclic lever excursion would have been sufficiently large or of sufficient duration to induce rotor mast oscillation.

A more likely possibility is that the briefcase fell off the sloping right hand end of the glare shield and struck either the pilot's legs or a rudder pedal. Either as a result of the fall or during the pilot's attempt to recover the briefcase, a sudden input may have been given to the cyclic control lever or to one of the rudder pedals. In support of this hypothesis there is the evidence that the briefcase was discovered sliced in two and lying high up in a tree not far from the position where the rotor head landed. This suggests the possibility that at the time of rotor head detachment the briefcase was lying on the cockpit floor forward of the pilot and was ejected by the rotor blade when it struck the nose of the aircraft from below and to starboard.

However, it again seems unlikely that the pilot, in attempting to retrieve the briefcase, would have inadvertently applied an input to the cyclic control of sufficient magnitude and duration to induce rotor mast oscillation.

The effect of a sudden input to one of the rudder pedals should not, in theory, lead to any serious control difficulties. However, the implications of the accident mentioned in para 1.17.2 where a similar input induced an upset manoeuvre which could well have (but apparently did not on that occasion) resulted in negative 'g' loading of the rotor blade with potentially disastrous consequences, cannot be disregarded.

A perplexing feature of the accident was the absence of any communication from the pilot on the final sector of the flight as he was known to make extensive use of the radio when airborne. Though he was not required to make a call on the Titchfield to South Marston sector, the pilot normally called Boscombe Down when passing the Andover Military Air Traffic Zone. Indeed both sets were found tuned to the Boscombe Down frequency and it is therefore probable that he tried but failed to make contact. Whether or not the

pilot's apparent communication difficulties were related to the accident could not be determined, but it seems unlikely. Had the pilot been distracted by some emergency condition to the extent that he was prevented from using the radio, then it could have been expected that he would have made a precautionary landing well before reaching the Inkpen area. However all the evidence points to the flight having been normal up to the moment of rotor detachment, which probably occurred with little or no warning.

2.2 Conclusions

(a) *Findings*

(i) The pilot was properly licensed and experienced on the type.

(ii) The aircraft had been maintained in accordance with an approved maintenance schedule and its documentation was in order.

(iii) An incorrect type of static stop was fitted to the main rotor mast. However this is not considered to have been a contributory factor to the cause of the accident.

(iv) Whilst in level cruising flight between Titchfield and South Marston, the rotor head became detached following the failure of the mast due to repeated bending.

(v) The bending and subsequent failure of the mast was caused by a severe oscillation of the rotor head.

(vi) There was insufficient evidence to establish positively the cause of the rotor head oscillation.

(vii) The possibility that the pilot's briefcase may have fallen sideways and downwards from the glare shield into the nose of the aircraft cannot altogether be dismissed. Had this occurred, it could have resulted in a sudden input to the cyclic control lever or a rudder pedal. Under certain conditions such an input might have induced rotor head oscillation.

(b) *Cause*

The accident was caused by a severe oscillation of the rotor head which led to the failure of the rotor mast and the complete detachment of the main rotor. No reason for the oscillation could be positively established.

3. Recommendations

It is recommended that Flight Manuals of all teetering rotor type helicopters include a suitable manoeuvring limitation to preclude negative 'g' flight, and that appropriate placards to this effect are required to be displayed in the cockpits of all affected aircraft.

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Accidents Investigation Branch
Department of Trade

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