ACCIDENTS INVESTIGATION BRANCH
Department of Trade and Industry

Hiller 360-UH 12 E Helicopter G–ATVN. Report on the accident at Balderton, near Newark, on 28 February 1972

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1973

List of Civil Aircraft Accident Reports issued by AIB in 1973

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13/73	Hiller 360-UH 12 E Helicopter G–ATVN at Balderton, near Newark, February 1972	September 1973

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Department of Trade and Industry
Accidents Investigation Branch
Shell Mex House
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16 July 1973

The Rt Honourable Peter Walker MBE MP
Secretary of State for Trade and Industry

Sir,

I have the honour to submit the report by Mr G M Kelly, an Inspector of Accidents, on the circumstances of the accident to Hiller 360-UH 12 E Helicopter G–ATVN which occurred at Balderton, near Newark on 28 February 1972.

I have the honour to be
Sir
Your obedient Servant

V A M Hunt
Chief Inspector of Accidents

Accidents Investigation Branch
Civil Aircraft Accident Report No 13/73
(EW/C403)

Aircraft:	Hiller 360-UH 12 E Helicopter G–ATVN
Engine:	Lycoming V0-540-B2D
Registered Owner and Operator:	Management Aviation Limited
Pilot:	Captain M F Higginson – Killed
Passenger:	Mr W K K Leong – Killed
Place of Accident:	Balderton, near Newark
Date and Time:	28 February 1972 at 1515 hrs
	All times in this report are GMT

Summary

The helicopter was on a positioning flight from Barnsley, Yorkshire, to Bourn, Cambridge. While flying level at approximately 70 feet in the vicinity of Balderton it was seen to jerk several times from side to side and then the main rotor became completely detached at the main gear box. The aircraft fell vertically on to arable land and caught fire. Both occupants were killed. The investigation revealed that the accident was due to the main rotor becoming detached in flight as the result of the failure, in fatigue, of a planet gear in the first stage reduction gearing.

1. Investigation

1.1 History of the flight

The helicopter had been engaged on line survey work for the Yorkshire Electricity Board.

On the day of the accident a replacement tail rotor had been fitted and then, after a static check, G–ATVN made a normal take-off from Barnsley to return to its home base at Bourn. On leaving Barnsley it was seen to be flying lower than usual but apparently satisfactorily.

The helicopter was next seen about half an hour later near Balderton, flying level in a southwesterly direction at approximately 70 feet, the witnesses' attention having been drawn to it by the sound of the engine faltering. They saw the fuselage jerk from side to side several times and the helicopter climb steeply for a moment before the main rotor became detached and the fuselage fell to the ground, where it caught fire. The rotor, still rotating, descended on top of the wreckage.

Both occupants were killed and the aircraft was destroyed.

1.2 Injuries to persons

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

1.3 Damage to aircraft

Destroyed.

1.4 Other damage

Slight damage to a growing crop.

1.5 Crew information

Captain Michael Frank Higginson, aged 39, held a valid Commercial Pilot's Licence (helicopters) issued on 14 September 1970 with Group 1 rating for various types of helicopter, including the Hiller 12 E. His certificate of test, dated 27 October 1971, was current and he had passed an appropriate medical examination on 1 February 1972.

His total flying experience amounted to 1,453 hours in command (with approximately 1,000 hours on helicopters), and included 21 hours on the Hiller 12 E.

He had flown 7½ hours during the preceding 28 days, all on the Hiller 12 E.

1.6 Aircraft information

1.6.1 The helicopter, serial number 2133, was manufactured by the Hiller Aircraft Corporation, United States of America in 1961. After service in Bermuda and Nigeria it was imported into the United Kingdom in 1966 and entered on the British Register as G–ATVN. A British certificate of airworthiness No A9092 was issued in the Public Transport category with effect from 21 June 1966 and had been renewed annually since that date. In April 1970 the helicopter was re-registered in the name of Management Aviation Limited.

Management Aviation Limited had maintained the helicopter to an approved maintenance schedule and at the time of the accident it had flown a total of 4,541 hours. The engine fitted to the helicopter at the time of the accident had been installed on 28 June 1971 and had run 620 hours since its last complete overhaul.

On 20 May 1971 G–ATVN was damaged during a heavy landing and was out of service until 28 June 1971.

On 8 February 1972 it sustained damage to the tail rotor and tail gearbox during a heavy landing due to a mechanical failure of the engine. Repairs were carried out, filters were checked, the engine and transmission oil was changed and the aircraft was certified as serviceable on 12 February 1972. The last entry in the technical log was dated 22 February and placed the aircraft unserviceable because of a cracked tail rotor blade. The tail rotor was replaced on 28 February, the day of the accident.

Calculation shows that the helicopter had an all up weight at take-off of 2,676 lb, (well within the maximum authorised), and that the centre of gravity was within the prescribed limits.

1.6.2 *Main transmission gear box No 723*

This gear box was originally installed in another Hiller helicopter built in 1961. After 1,050.20 hours total running it was completely overhauled in May 1970. In July 1971 it was stripped during a Check 3 inspection after a further 499.50 hours running and, at this time, contamination by copper dust originating from the bronze spacer washers of the first stage planetary gears was discovered within the gear box casing.

The washers themselves were found to have worn below the minimum thickness allowable and were replaced. The inspection report evoked by these circumstances does not record the cause of this wear. The visual inspection of the planet gears for evidence of overheating or cracking that was made was not noted in the records. The gear box was then installed in G–ATVN on 18 September 1971.

At the time of the accident the main transmission had run a total of 1,859 hours, including 808 hours since complete overhaul and 309 hours since the Check 3 inspection and rectification referred to above. The authorised life between complete overhauls is 1,200 hours.

1.7 Meteorological information

The weather, which was good, is not considered to have been of significance in this accident.

1.8 Aids to navigation

Not relevant.

1.9 Communications

Not relevant.

1.10 Aerodrome and ground facilities

Not relevant.

1.11 Flight recorder

Not required and not fitted.

1.12 Wreckage

1.12.1 The helicopter had struck the ground in an almost vertical attitude. Following this impact it had caught fire and the front fuselage and engine were severely damaged. A trail of fragments from the main transmission gear box and casing extended for some 50 metres in a northeasterly direction. The main transmission had separated at the centre gear casing which had broken up into several pieces and, as a result of this disruption, the complete main rotor had separated from the aircraft. It was apparent that the rupture of the casing had resulted from the gross distortion of the first stage planet gear ring which is positioned in, and keyed to, the centre casing.

1.12.2 When the gear box was dismantled one of the first stage planet gear pinions was found to have disintegrated and a fragment of it had become interposed between another of the planet gear pinions and the first stage planet ring gear. The gross distortion so caused burst open the gear box casing releasing the main rotor and its drive shaft.

The other two planet gears, although showing secondary damage, were intact and their needle bearings were satisfactory. All the bronze spacer washers were *in situ*. Those of the broken gear were mutilated but all washers retained at least part of their lead surface coatings and there were no signs of overheating on them. Their thickness was measured and found to be satisfactory. Although the lead coating on the face of the top spacers of the gears showed some wear, it is considered that the pick up observed on the planet carrier upper bush flanges indicated a much greater degree of abrasion than the condition of the spacer washers would suggest.

A physical check showed that all mandatory modifications had been incorporated. Inspection of the transmission oil supply system showed that the oil pump drive was intact, the oil cooler was unobstructed, the oil supply pipes were clear and the filter clean. There was ample oil available.

Strip inspection of the engine revealed no pre-crash mechanical defect or failure and lubrication throughout had been satisfactory.

1.13 Fire

Fire occurred on impact, destroying the cockpit and forward part of the helicopter.

1.14 Survival aspects

The accident was not survivable.

1.15 Tests and research

The planet carrier, gears and spacers were subjected to a detailed examination by the Materials Department at the Royal Aircraft Establishment, Farnborough.

One of the three planet gears was found to be fractured in several places. The segments bore deep identations that coincided with the pitch of the teeth, and the other two planet gears were similarly indented, indicating that the broken segments had been trapped in the system. One of the fracture faces was relatively smooth compared with the rest, which exhibited ductile overload features. On one of the other fractures a small, smooth quadrant-shaped area was noticed at one inside corner. The top end face of the fractured planet gear was found to be discoloured and craze cracked in a manner indicative of over-heating resulting from friction, and there were a number of fatigue cracks which had been initiated at craze cracks. Over-heating on the hardest surface resulted in a tempered zone, beneath a surface layer of martensite, 220 microns (0.009 inches) deep.

Discolouration and craze cracking were present to a lesser degree on the top end face of one of the other two planet gears but these effects were not observed on the third.

The spacers associated with the fractured gear were badly damaged by the break-up of the gear but it was possible to see that, where the lead overlay had not been scraped off, a good thickness remained and that there was no evidence of overheating. The spacers from the other two gears, though showing some uneven wear, were generally in good condition with the lead overlay substantially intact.

Examination of the planet carrier revealed that the flanges of the lower steel bushes were in good condition but the upper bush flanges in the positions relating to the fractured gear, and the other gears that showed discolouration and craze cracking, exhibited evidence of severe over-heating and pick up of copper.

The planet gear spindles showed no sign of having been exposed to high temperatures but a slight groove existed in the top spacer position on the spindle of the fractured gear. The edge of the hole in the related spacer was not damaged in a manner consistent with this groove.

2. Analysis and Conclusions

2.1 Analysis

It can be seen from the evidence that one of the first stage planet gears had disintegrated and a fragment of the gear had become wedged between another planet gear and the gear ring. The consequent gross distortion of the gear ring, which is fixed to the centre casing, resulted in complete disruption of the casing and detachment of the main rotor.

There was no evidence of lack of lubrication or seizure in the gear box and all the mandatory modifications had been embodied. Metallurgical examination however, revealed areas of overheating due to friction on the top face of the failed gear, and signs of pick up of copper on two of the upper bush flanges. Microscopic inspection revealed a number of craze cracks on the top face of the failed gear and one other gear, and a number of fatigue cracks that had initiated from the crazing. It is concluded that the failure of the planet gear was due to fatigue cracking, initiated at one of the overheating cracks on its top face.

In view of the satisfactory condition of the lead coated copper spacer washers installed with the planet gears and the evidence of ample lubrication available at the time of the accident, it must be inferred that the overheating of the steel planet gears and the deposit of copper did not take place while the gear box was installed in G–ATVN. It must, therefore, have occurred prior to the last rectification of this gear box in July 1971 while the gear box was fitted to another helicopter. Although the inspection report made at this time does not indicate the cause of the excessive wear of the copper spacers that were replaced during the rectification, or refer to inspection of the gears for evidence of overheating or cracking, it was learned after the accident that a visual inspection had been made at the time and that no discernible indication of overheating was found. The craze cracks and fatigue cracks revealed under the microscope would not have been discernible at a visual inspection.

It has not been possible to trace any record of overheating during the earlier life of the gear box during the investigation and no such record was available to the engineering and inspection staff who made the Check 3 inspection.

In the absence of any directive that special crack detection techniques should be applied or microscopic examination carried out at Check 3 inspections, and of any discernible evidence of overheating, no action of this sort was taken. The gears were accepted as satisfactory and re-installed in the gear box.

2.2 Conclusions

(a) *Findings*

(i) The aircraft documentation was in order and the helicopter was correctly loaded for the flight.

(ii) The pilot was correctly licensed and competent to conduct the flight.

(iii) A planet gear in the first stage reduction gearing disintegrated and part of it became wedged between another planet gear and the gear ring in the casing, causing the gear casing to burst apart and the main rotor to become detached in flight.

(iv) The break-up of the planet gear was due to a fatigue crack initiated by craze cracking due to overheating.

(v) The overheating occurred some time before the last Check 3 inspection of the gear box, when the box was installed in another helicopter.

(vi) No record was found of overheating during the earlier life of the gear box.

(b) *Cause*

The accident was caused by the main rotor becoming detached in flight as the result of the failure in fatigue of a planet gear in the first stage reduction gearing.

3. Recommendations

It is recommended that consideration be given to the greater use of crack detection techniques and microscopic examination of highly stressed components in inspection procedures, particularly where unusual features come to light during routine checks.

G M Kelly
Inspector of Accidents

Accidents Investigation Branch
Department of Trade and Industry
July 1973

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