INCIDENT

Aircraft Type and Registration:	Aerospatiale AS355F1, G-FFRI
No & Type of Engines:	2 Allison 250-C20F turboshaft engines
Category:	2.2
Year of Manufacture:	1982
Date & Time (UTC):	19 July 2004 at 0945 hrs
Location:	Near Lasham Airfield, Hampshire
Type of Flight:	Public Transport
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to right engine drivetrain and coupling housing tube
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	7,200 hours (of which 1,800 were on type) Last 90 days - 60 hours Last 28 days - 18 hours
Information Source:	AAIB Field Investigation

History of the flight

The pilot had flown passengers from Lasham to the Farnborough Airshow and was returning to Lasham empty. Whilst approaching Lasham in the cruise at 1,500 ft amsl and 120 kt IAS, a thump was heard from an indeterminate source. On checking the engine instruments, the pilot noticed that the No 2 engine was indicating ground idle rpm. He shut down the engine and performed an uneventful single engine landing at Lasham. The pilot recalled that whilst on the ground at Farnborough he had felt an unusual high frequency vibration that he could not trace.

Background

This incident was reported to AAIB by the operator who initially believed that it may have been related to Eurocopter Alert Telex 63 00 21 that addressed problems with combining gearboxes delivered new, or newly overhauled and fitted with freewheel rollers finished with an incorrect surface coating applied. The combining gearbox fitted to G-FFRI did not fall into the category of combining gearboxes affected by the Alert Telex (and corresponding EASA Airworthiness Directive) and, as described later, there appears to be no connection between the incident and freewheel problems.

Examination of the aircraft

G-FFRI was examined in the owner's hangar at Lasham. Externally it appeared completely undamaged but upon lifting the cowling of No 2 engine it was clear that the flexible coupling (often referred to as a 'Thomas' coupling) between the engine drive shaft and the combining gearbox had disintegrated and the coupling housing tube in which the shaft runs had been shattered as a result.

The coupling housing tube is a structural part of the engine accessory gearbox (see Figure 1) and is attached to the combining gearbox via a universal, or gimbal, joint. This is because the coupling housing tube is a fundamental part of the engine mounting structure. The engine itself is mounted on a single elastomeric point and the housing tube-to-combining gearbox attachment forms the second element to locate the engine. In the absence of the latter, the engine is free to rock laterally and longitudinally around the single bolt in the elastomeric mount. The No 2 engine of G-FFRI was in this condition since the universal joint had been destroyed by the flailing Thomas coupling/drive shaft. The coupling itself had broken into scores of pieces and was distributed around the Main Rotor Gearbox (MRGB) compartment.

Because of a high workload the operator was unable to progress removal of the affected transmission and engine components for some weeks and it was agreed that these would be forwarded to Eurocopter, together with the fragments of Thomas coupling, for examination.

Previous cases of coupling failure

The Thomas coupling is widely used in helicopters for any application in which torque is transmitted by a shaft which is subject to small variations in alignment. Such misalignments (maximum 1° 30') are absorbed by, in this case, a 14-element 'sandwich' of thin stainless steel leaves (flector leaves). Continued operation of the coupling with misalignments greater than this can lead to fatigue fractures of individual elements and, if not detected, this in turn can lead to failure of the entire assembly.

Misalignment of the engine/transmission can occur due to deterioration of either the transmission or engine mounts. In the AS355F1 model helicopter, torsional loads on the MRGB are reacted by four elastomeric pads attached to the upper fuselage deck. As described above, one element of the engine mount also uses elastomeric suspension and thus any significant deterioration of the elastomers can lead to relative movement of either the MRGB or engine.

On 8 December 1992, another AS355F1 helicopter, registration G-OHMS, suffered a similar failure of the Thomas coupling of the No 2 engine. An uneventful single-engine landing was also achieved without damage to the helicopter. The AAIB report on this incident (AAIB Bulletin 1/94), noted that there had been four previous cases of coupling failure known to the manufacturer, one of which had been the subject of an earlier AAIB field investigation (AAIB Bulletin 12/91, registration G-WMPA). The other three were, according to the manufacturer, considered to be due to deterioration of the MRGB elastomeric mounts.

No significant deterioration of the MRGB mounts was found on G-WMPA but, in the case of G-OHMS, a number of the elastomeric laminated pads were found to have deteriorated to the extent that, in the manufacturer's opinion, MRGB location could have been compromised. It was concluded that this was probably responsible for the Thomas coupling failure.

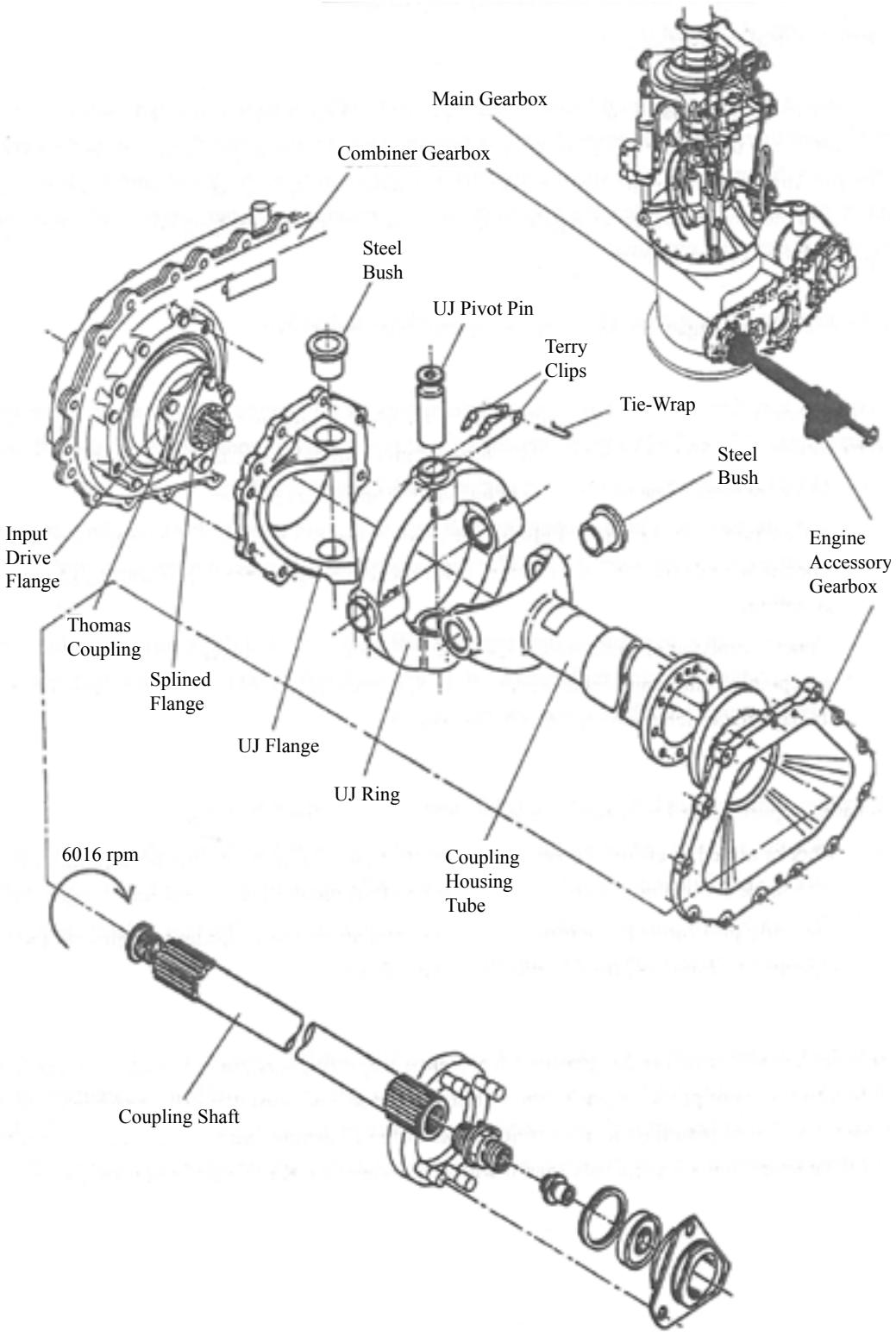

Figure 1

Engine to Main Gearbox Drive Train - exploded view

Interrogation of the CAA's Mandatory Occurrence Report database suggest that no additional complete Thomas coupling failures had occurred in the UK between the G-OHMS and G-FFRI incidents but it was noted that some 11 cases of discovery of cracked or even broken leaves are recorded, including one in August 2004.

Subsequent examination of G-FFRI

The MRGB and combining gearbox were despatched, via Eurocopter's UK agent but not under AAIB supervision, to the factory at Marignane. Inspection showed no evidence of freewheel slippage or other problems but it appears that the fragments of Thomas coupling, including the coupling flange bolts, and the coupling housing tube, which the operator insists were packed with the MRGB, were missing and have not been recovered.

Inspection of the MRGB elastomeric suspension did not reveal any significant deterioration. The engine mounting was submitted for laboratory examination by the AAIB to determine whether visible damage to the elastomer was indicative of deterioration. The examination found that there were no significant material property differences between the mount from G-FFRI and a new, unused, item.

The former was found to be some 3.7 mm shorter than the latter, apparently due to settling of the elastomer under the weight of the engine in-service. This is not considered significant in terms of the degree of misalignment at the Thomas coupling.

Discussion

The reports into the G-OHMS and G-WMPA incidents describe the various factors which could be instrumental in failure of Thomas couplings, namely:

1 Degraded MRGB bilateral suspension
2 Relaxed torque on the Thomas coupling flange bolts
3 Disconnection of the gimbal joint on the coupling housing tube due to loss of a quick-release 'Terry' clip

It is evident that degradation of the engine elastomeric mount should be added to this list, since it appears to have the same potential as a degraded MRGB suspension to provoke misalignment leading to fatigue cracking of the flector leaves.

No evidence was found that either item No 1 or item No 3 above were responsible for the failure of the Thomas coupling of G-FFRI. It is regrettable that any evidence regarding the condition of the coupling flange bolts seems lost, particularly in the light of a discovery made by the same maintenance company in January 2005 and brought to the attention of the AAIB. During routine maintenance on an AS355F2 helicopter (not G-FFRI), it was necessary to dismantle the engine drive Thomas couplings. Four of the six nuts and bolts seemed quite normal but two showed signs of severe frettage of both the nut and the bolt, apparently caused by a loose-fitting split pin (Figure 2). The pins themselves were intact but, as can be seen from Figure 2, the loss of material from the nut is considerable. Informal contact with another maintenance company suggested that they, too, had experience of this phenomenon as did an AAIB consultant metallurgist who had observed it in applications other than helicopters. The helicopter had flown a total of 5,597 hours since new and the combining gearbox had a total of 1,072 hours since overhaul (overhauled gearboxes are supplied with new Thomas couplings and hence bolts).

The remedy for this potentially hazardous condition would appear to be fairly simple, therefore whilst there is no evidence that the failure of the coupling from G-FFRI was related to the issue of split-pin frettage, the following Safety Recommendation is made:

Safety Recommendation 2005-081

It is recommended that Eurocopter review the design, or maintenance procedures adopted for the installation, of 'flector' couplings to ensure that the potential for fretting of the split-pin/nut/bolt assembly is eliminated.

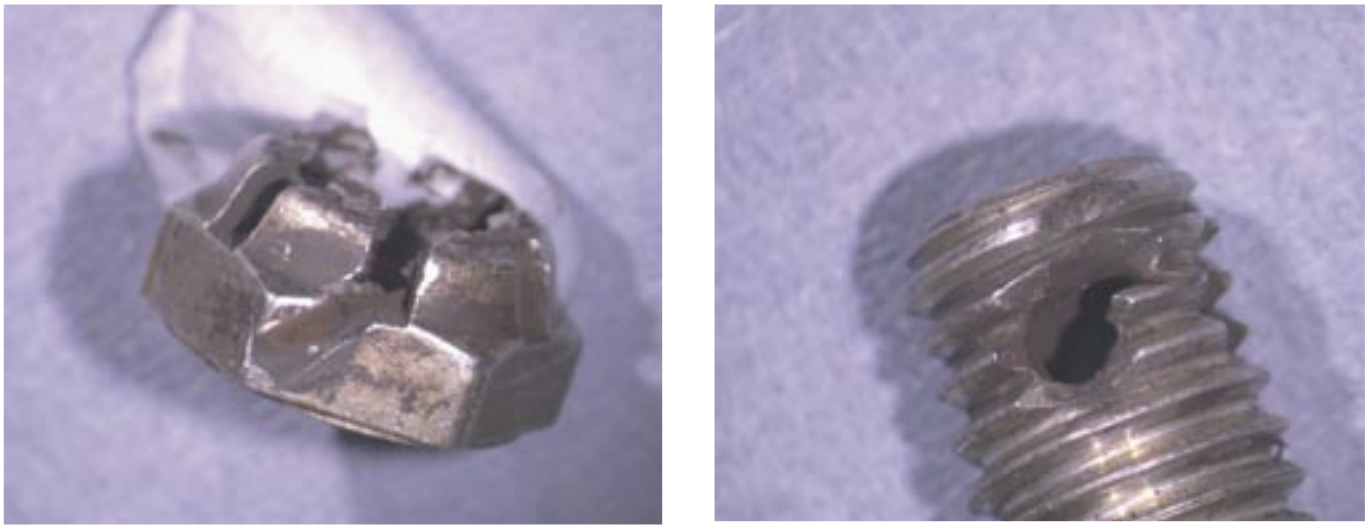

Figure 2

A coupling flange nut and bolt removed from a Thomas coupling fitted to an AS355 helicopter showing severe fretting caused by a loose-fitting split-pin