AAIB Bulletin No: 8/94 **Ref: EW/G93/12/02** **Category: 1.3**

Aircraft Type and Registration:	Cessna F177RG Cardinal RG, G-AZTF
No & Type of Engines:	1 Lycoming IO-360-A1B6 piston engine
Year of Manufacture:	1972
Date & Time (UTC):	3 December 1993 at 1039 hrs
Location:	0.5 miles south west of Guildford, Surrey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - None Passengers - None
Nature of Damage:	Substantial damage to fuselage, landing gear, right wingtip and horizontal stabiliser; internal damage to engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	24 years
Commander's Flying Experience:	222 hours (of which 4 were on type) Last 90 days - 4 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB enquiries

The aircraft was in the cruise at 2,400 feet when a burning smell was noted after the cabin heat control had been adjusted. The heater was shut off, but the pilot then noticed that the engine oil pressure was dropping rapidly. This was followed immediately by severe vibration, which occurred some 20 seconds after the burning smell became apparent.

The passenger in the right hand front seat was an ATPL holder with more than 2,500 hours experience as pilot in command, and was also a flying instructor. He took control of the aircraft and transmitted a 'MAYDAY' call to Farnborough. The engine was vibrating so badly that it was shut down. An emergency landing using full flap was made into a ploughed field, but the aircraft bounced twice and went through a wire fence before striking a second, more substantial fence. This removed the nose landing gear and caused the aircraft to slew through 90° to the right before coming to a halt. The occupants, who were uninjured, evacuated the aircraft via both doors. The police attended shortly afterwards, and an Army helicopter landed nearby and offered assistance.

Subsequent examination of the engine revealed that the failure had been caused by a loss of drive to the oil pump due to a Woodruff key, on the pump impeller drive shaft, having completely worn away. The resultant loss of oil pressure had caused seizure of the main bearings and disintegration of the No 2 big end bearing. Photographs of the oil pump components are shown at Figure 1.

This type of oil pump failure is a known problem affecting a large range of Lycoming four and six cylinder engines, and the component has been the subject of a number of Service Instructions (SIs), Service Bulletins (SBs) and Airworthiness Directives (ADs). Briefly, Service Instruction 1230, issued in 1970, introduced sintered iron impellers and Woodruff keys. Wear problems with the latter led to Service Bulletins 381 and 385 (essentially the same modification, but applicable to different engine models) which changed the Woodruff key to a flat drive, with the sintered iron impellers being retained. This was mandated by FAA Airworthiness Directive 75-08-09 which, as with all FAA ADs, also applied to UK registered aircraft. SB 385 required compliance within the next 50 hours of operation for all engines that had accumulated more than 400 hours from new, or since last overhaul.

Impeller problems resulted in Service Bulletin 456 in 1981, which introduced a hardened steel driving impeller and aluminium driven impeller. However, the latter was changed to steel with the latest revision of the Bulletin, 456F, which was dated February 1993. SB 456 was mandated by FAA Airworthiness Directive 81-18-04, which called for compliance with SB 456 or FAA approved revision or alternate, at 2,000 engine hours since new or since last overhaul, whichever the later. However, there is an associated inconsistency in that SB 456 calls for compliance within 100 hours. The Directive notes that compliance is also required for those engines that have already complied with Service Instruction 1230, and SBs 381 and 385. It is not understood, therefore, why AD 75-08-09 still appears applicable. The situation is further complicated by the fact that SB 456 is itself a revised version of SB 455, with an additional batch of serial numbers in the applicability list, and less stringent compliance times.

In the UK, applicable oil pumps were the subject of an Additional Airworthiness Directive (AAD), No 0774. This basically endorsed FAA AD 75-08-09, but brought it into line with the requirements of Airworthiness Notice No 35, which deals with operation of engines beyond constructors' recommended overhaul periods. This AAD has never been revised.

The engine from G-AZTF had achieved 1,970 hours at the time of the accident, and had the SI 1230 standard oil pump; SB 385 had not been embodied although, for reasons that could not be established, it was not applicable by serial number. The engine log book contained the incorrect statement to the effect that AD 81-18-04 was not applicable. In fact it would have been due at the 2,000 hour overhaul. However, had the engine been equipped with 'dual drive' magnetos, the work would have been required to have been accomplished within the next 25 hours.

The chief engineer of the maintenance organisation that examined G-AZTF has observed that on a number of engines returned for overhaul, the Woodruff keys of the associated oil pumps had suffered severe wear, although failure had not actually occurred. A related problem was the difficulty experienced in establishing the modification state of the engine. Aircraft imported from the USA with an Export Certificate of Airworthiness do not always have a complete list of the associated SIs and SBs that have been embodied.

It is thus apparent that there is some confusion amongst operators as to the applicability of the various SIs, SBs and ADs, together with their subsequent revisions. It is also apparent that there are engines in service that are equipped with the SI 1230 standard Woodruff key type oil pumps, and that their ability to continue in service until engine overhaul is questionable.

The following safety recommendation has therefore been made to the CAA:

94-8 It is recommended that the CAA requires Lycoming piston engines to be inspected to ascertain the modification standard of associated oil pumps, and that all oil pumps to SI 1230 standard (ie Woodruff key drive types) are required to be replaced with pumps of the latest standard as soon as practicable to prevent related engine seizure due to a sudden loss of drive/oil pressure.

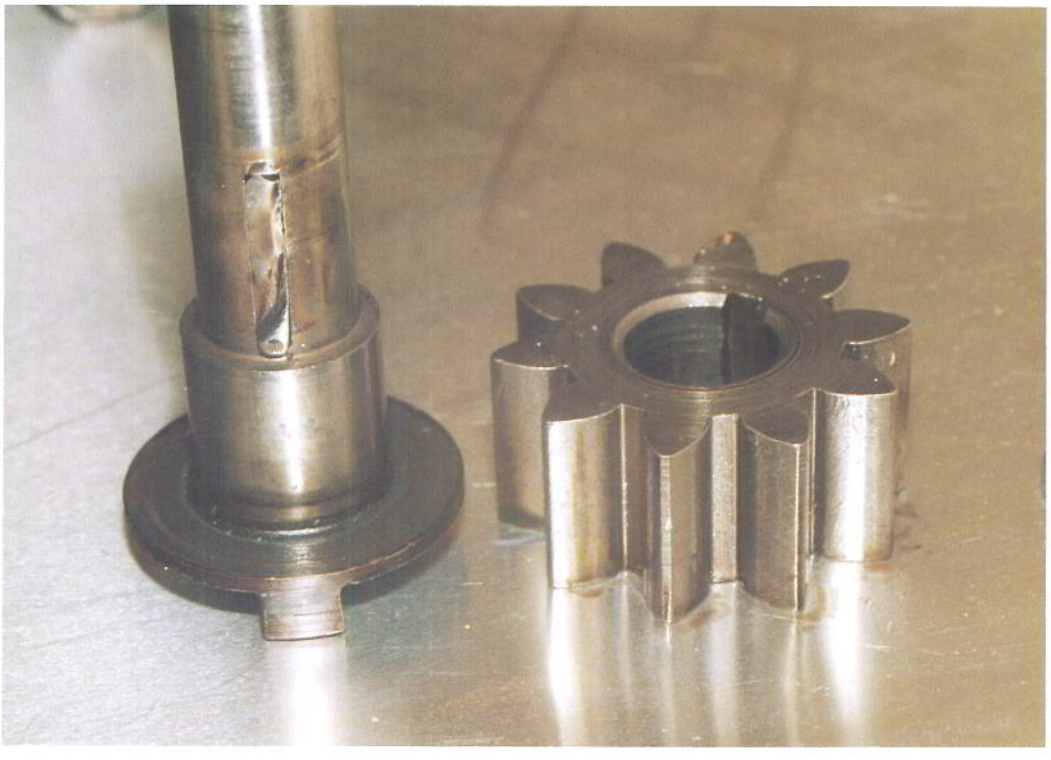

FIGURE 1. Oil pump from G-AZTF, showing worn Woodruff key