AAIB Bulletin No: 8/93 **Ref: EW/G93/04/17** **Category: 1c**

Aircraft Type and Registration:	Piper PA-34-200T Seneca II, G-BORH	
No & Type of Engines:	2 Continental TSIO-360-EB piston engines	
Year of Manufacture:	1980	
Date & Time (UTC):	30 April 1993 at 1630 hrs	
Location:	Shoreham Airport, West Sussex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to right main gear, right flap, fuselage underside and left propeller	
Commander's Licence:	Commercial Pilot's Licence with Instrument and Instructor Ratings	
Commander's Age:	46 years	
Commander's Flying Experience:	1,230 hours (of which 145 were on type) Last 90 days - 28 hours Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and metallurgical examination of failed right gear leg.	

Following an uneventful flight from Rouen the aircraft had made an approach to Runway 21 at Shoreham Airport when, following a reported normal touchdown, it suddenly began to veer to the right. Considering that it would be dangerous to continue with the landing, the pilot made the decision to go-around. As the aircraft climbed away, one of the rear passengers informed the pilot that he could see the right main landing gear, which was trailing in the slipstream with hydraulic fluid leaking away. A later flypast of the tower confirmed that there was major damage to the right gear leg and so the pilot elected to burn off fuel to the south of the airfield in order to reduce the fuel quantity to a reasonable minimum. During this two hour period the opportunity was taken to comprehensively brief the passengers, and the emergency services were also alerted by the controller. At 1620 hours the pilot carried out a precautionary approach to Runway 25 (grass) in order to assess the visibility 'into sun', and the wind strength. Ten minutes later, with the right engine stopped and its propeller feathered, the aircraft was landed with the landing gear down at a speed of around 70 kt. During the initial landing roll, the right wing lifted and the left propeller blade tips made contact with the ground. After coming

to rest, the occupants (who were uninjured) were able to make their escape within a few seconds. There was no fire. The landing sequence is shown at Figure 1.

After the aircraft had been recovered to its maintenance organisation on the airfield the failed right main gear was removed and taken for examination by the AAIB. A complete failure had occurred around the lower end of the oleo trunnion assembly housing at a position coincident with the runout of a large fillet between the leg barrel and aft trunnion, as shown in Figure 2. The majority of the fracture face exhibited evidence of an overload type of failure, but in the region where the fillet blended into the barrel, which was coincident with a forging 'flash-line', there were progression bands that were typical of those produced by a high stress, low cycle, tension fatigue mechanism. The paint on the barrel immediately adjacent to the fracture in this area contained a large number of stress-related and smaller cracks. In addition, cracks which appeared to be secondary open cracks in the barrel surface could be seen through the cracked paint, which is illustrated in Figure 3. The relative location of the cracks in the paint showed that the leg, at some time, had been subjected to an abnormally high level of forward flexing. Hardness and conductivity measurements on the material of the housing indicated that it had been fully heat-treated and was materially satisfactory.

In view of previous instances of such failures on PA-34 aircraft, the subject portion of the leg was stripped of paint and examined generally for corrosion and cracks. Extensive corrosion was present on part of the barrel wall and on one face of the fillet, as shown in Figure 4. This appeared to be a region from which paint had previously been removed, presumably in accordance with Service Bulletin 747A (see later), and coincided generally with the area of stress-cracking in the paint. The total area of fatigue damage on the fracture surface contained at least three positions where cracking from a tension fatigue mechanism had initiated. This area had also been attacked by corrosion, with associated pitting. From its appearance, this fracture had progressed over a considerable time (Figure 5). A section of material from this area, close to the fracture initiation site, was removed and prepared so that the associated cracks could be examined. This showed that these cracks were typical of those produced by a slow stress-corrosion mechanism. Figure 6 shows one example where a fatigue crack had started to develop from the inner end of a stress corrosion crack, but had not progressed to failure.

These cracks were in an area subject to mandatory inspections at 100 hours intervals under Piper Service Bulletin 787A, initially issued in 1985, and CAA AD 002-01-88, both of which also apply to the Piper PA 44 Seminole aircraft. On the subject aircraft the fillet ran out into the barrel approximately 4.3 inches above the bottom of the housing; on later standard housings this fillet runs out 1 inch further down. The mandatory inspection requires that such areas are inspected visually for cracks using a x10 magnifying glass, after the surface in the affected area has been exposed. On the subject leg there were signs of a dye penetrant in most of the paint layers exposed during the examination, but

there was no evidence of dye staining on the fatigue crack surfaces. The aircraft's maintenance records showed that G-BORH had been subjected to SB747A on ten occasions, within the required 100 hour periods, since it was imported into the UK in November 1988. The last inspection recorded was seven weeks, 19 hours, prior to the accident.

Since 1985 there have been four similar failures on PA 34 aircraft reported in AAIB Bulletins. These housings did not feature the modified, extended fillet. They were as follows:-

G-BBZJ	5 April 1987	Bulletin 9/87, inspected 30 hours before failure
G-CJWS	6 July 1991	Bulletin 10/91, inspected 7 hours before failure
G-TEST	25 August 1991	Bulletin 10/91, inspected 93 hours before failure
G-FILE	15 June 1992	Bulletin 11/92, inspected 54 hours before failure.

Also, over the same period a significant number of aircraft have been found with cracks in the same location, on modified housings.

Safety Recommendation

It is evident from the above that the current inspection requirements are a quite inadequate means of identifying stress-corrosion, or corrosion-induced fatigue cracks, in such gear housings. Stress corrosion is a calendar time dependent mechanism and is not influenced to any general extent by flying life, unlike any resulting fatigue cracks. It is also evident that standing internal tension stresses within the forging, resultant from manufacture (which may be exacerbated by heavy landings which may not result in fracture or cracking) can leave the housing susceptible to stress-corrosion cracking, particularly if the protective paint layer is less than complete. In-situ visual or dye penetrant inspections to find cracks which may be packed with corrosion products, and possibly wet, are not considered a reliable means of identifying this type of damage. It is considered by personnel experienced in non-destructive testing techniques that an eddy current method would be more likely to detect such flaws, with a high degree of probability.

In October 1991, following the investigation of a landing gear housing failure on G-TEST, the AAIB made a Safety Recommendation that:-

"The CAA review the requirements of AD 002-01-88 with particular reference to the quality of the required inspection, its periodicity and re-protection of the affected area after each inspection."

This was re-iterated in Bulletin 11/92 following the failure which occurred on G-FILE. The CAA accepted this Recommendation in 1991, but pointed out that the FAA was also reviewing the matter and the CAA were, therefore, awaiting notification of any FAA action at that time. That Recommendation thus remains valid, and the required action outstanding. As a result of this latest failure, the following Safety Recommendation has been made to the CAA:

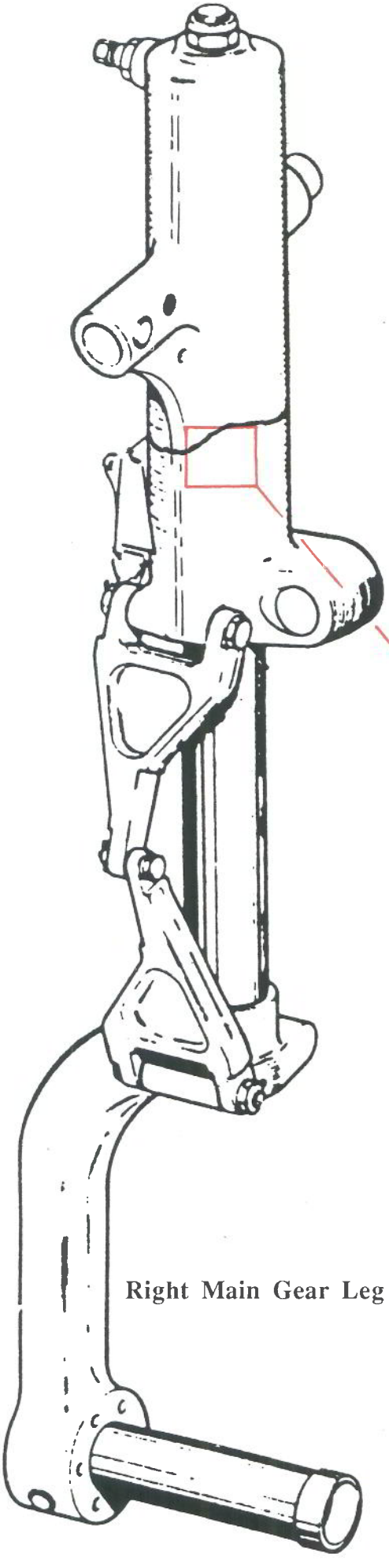
93-43 The CAA should expedite a review of the requirements of AD 002-01-88 with particular reference to the methods of the required inspection, its periodicity in terms of calendar time and flying time, and associated requirements for re-protection of the affected areas of Piper PA-34 Seneca and PA-44 Seminole aircraft landing gear leg housings, with a view towards limiting the rate of associated gear leg failures.

Seneca II G-BORH Landing

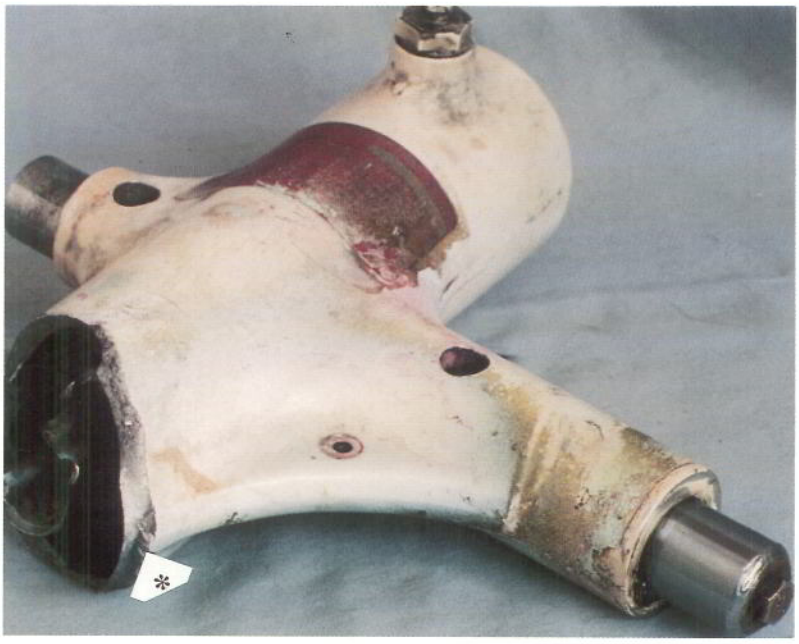
Shoreham - 30 April 1993

Pictures Courtesy of BBC Television South Today

Figure 1



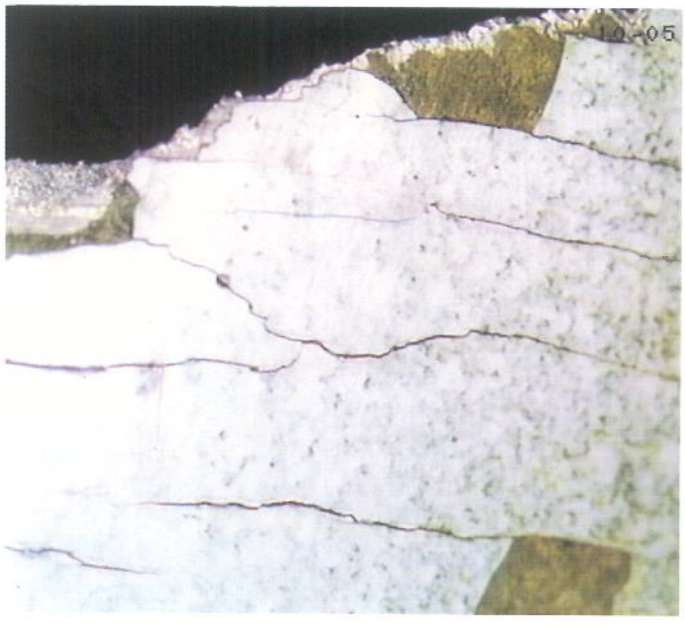
Right Main Gear Leg Assembly



Fracture Location
Asterix denotes Fatigue/Stress Corrosion Area

Note dye stains on paint
and under washer area

Figure 2



Stress Cracks in Paint

Figure 3

Figure 4

General Surface Corrosion Revealed Below Paint on Face of Fillet

Figure 5

Detail of Fatigue Area Showing Multiple Crack Origins and Corrosion Staining of Crack Surface

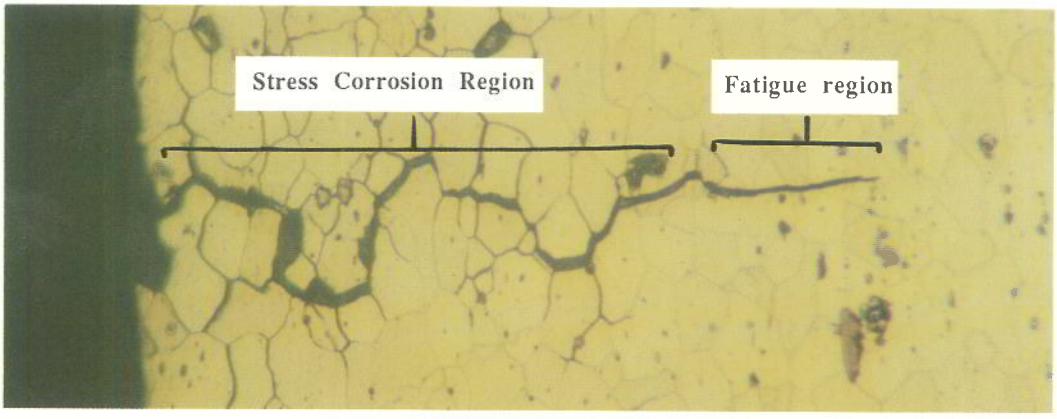


Figure 6

Micro Section of Typical Stress Corrosion Crack (Intergranular) Running to a Fatigue Crack (Transgranular)