No: 2/88 **Ref: 1c**

Aircraft type and registration:	Stampe SV4C/G G-ATKC	
No & Type of engines:	1 Gypsy Major 10-1 piston engine	
Year of Manufacture:	1949	
Date and time (UTC):	2 August 1987 at 0952 hrs	
Location:	Shingay, near Royston, Hertfordshire	
Type of flight:	Private (pleasure)	
Persons on board:	Crew — 1	Passengers — 1
Injuries:	Crew — 1 (fatal)	Passengers — 1 (fatal)
Nature of damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	41 years	
Commander's Total Flying Experience:	600 hours (of which approximately 185 were on type)	
Information Source:	AAIB Field Investigation	

History of the Flight

The aircraft was operating from a small airstrip on a farm where its owners, an aerobatic and sport flying club, were holding a 'weekend fly-in'. It had been flown there by club members from its normal base at Redhill on Friday and operated without incident during Saturday when aerobatics and spot landings were performed. The aircraft was regularly used for aerobatic practice and competitions.

On the morning of the accident, the pilot was seen to make a thorough pre-flight inspection of the aircraft after he had assisted with its refuelling. He then helped his passenger, who was also a pilot qualified on type, into the front seat before he strapped himself into the rear cockpit. Another club member primed the carburettor, fastened the engine cowlings and hand-swung the propeller to start the engine. Run-up checks were performed and then the aircraft took-off at about 0930 hrs and departed in a south-easterly direction.

Just east of the inactive airfield at Bassingbourn, the aircraft was seen to perform some normal aerobatic manoeuvres. It was in this area for about 10 minutes and it was only when the engine note was silent for an abnormally long time that eyewitnesses turned their attention to the aircraft. It was seen at a height of about 600 feet, in a spiral dive. The left wings were folded-back alongside the fuselage and some witnesses could hear them "flapping" in the slipstream as the aircraft rotated in a clockwise direction. Other witnesses had heard a sharp cracking noise which had caused them to look up at the aircraft. No large pieces were seen to fall from the aircraft but a portion of the left wing, which was later identified as part of an aileron, fluttered into a field adjacent to the impact point. A short burst of engine power was heard before the aircraft crashed into a stubble field. Both pilots were killed instantly.

The weather at the time of the accident was fine with good visibility, a north-westerly wind of 10 knots and 5 oktas of stratus cloud at 1400 feet.

Examination of the wreckage

It was apparent that the aircraft had dived into the ground in a near vertical attitude. The engine had penetrated the ground to a depth of 5 feet, and leading edge damage that was found on fragments of the propeller indicated that the engine had been turning at impact.

Debris from the aircraft was found scattered over an adjoining field of unharvested rape to the south of the main wreckage. The debris included the outboard portion of the left upper aileron; the fairing-strip between the underside of the lower left wing and the fuselage; a similar strip from the left upper wing and the centre section; a piece of windshield perspex and numerous wooden fragments from the internal structure of the wings. Some of the debris was found up to 400—500 yards from the main impact.

Following an on-site examination, the wreckage was taken to AAIB's facility at Farnborough for a detailed examination.

It was found that there had been a fatigue failure in each of the two steel tie-rods that effectively link together the main spars of the lower mainplanes across the fuselage, (see attached drawing). The rods lie alongside a 32 mm diameter steel tube which reacts compressive forces imparted by the undercarriage during landing. However, this tube is placed in tension when the aircraft is airborne. The tube terminates at the inside face of each fuselage sidewall, and two short bolts attach it, via flanges on the upper arc of the tube ends, to a steel casting on the outside of the fuselage sidewall. The tie-rods pass through both the sidewalls and the castings, and are retained by nuts on the threaded ends of the rods. The design of the aircraft is such that the effect of aerodynamic lift and drag on the wings is to apply predominantly tensile forces on the tie-rods. The CAA had set a 500 hour life on these components, and the aircraft log books showed that they had been replaced in May 1986 prior to the renewal of the Certificate of Airworthiness. Subsequently the aircraft had flown approximately 365 hours up until the time of the accident. It was noted that neither of these tie-rods, nor any of those subsequently examined during the course of the investigation, bore any serial or part numbers.

The failures had occurred within the threaded areas of the left-hand ends of each tie-rod. The rod-ends and nuts were not recovered. A metallurgical examination revealed that the fatigue in the rear rod had started from multiple origins in the thread root on the underside (relative to the aircraft axes) and had progressed upwards until complete failure had occurred. The forward rod fatigue origins were on the forward/underside quadrant of a thread root, and the crack progressed rearwards and upwards until the rod failed in overload over the last 25% of the section. The "smoother" nature of the fatigued surface on the rear rod implied that this had been a comparatively high cycle fatigue (i.e. low stress, large number of load applications). This in turn suggested that the rear rod had started to fatigue before the forward one. When complete failure of the rear rod had occurred, additional stress would have been place on the forward rod, resulting in a faster rate of crack propagation. Ultimately the effective cross-sectional area of the rod would have been reduced to the stage where a comparatively small load application would have resulted in complete failure. It was not possible to assess the length of time the entire process took, although it is considered that a large number of flights was involved.

Additional metallurgical examination revealed the presence of a small fatigue crack in the thread root of the right-hand end of the rear tie-rod. The crack was in the upper quadrant of the rod and had progressed through some 10% of the section. The material was checked against its specification of S96 steel and it was found to conform. Furthermore, there were no stress-raising features, such as corrosion pits, in the areas of the fatigue origins.

The bolts that attached the left-hand end of the undercarriage compression member to the steel casting had failed in bending. Following the final tie-rod separation, the steel casting would have tended to pivot about its upper edge. Clearly these bolts were unable to prevent

this, and only limited restraint would have been provided by the undercarriage leg, which is attached to the same casting. Thus, the left wings would have tended to fold upwards and rearwards, at which point all control of the aircraft would have been lost.

Stampe tie-rods were the subject of a Service Bulletin, issued by Aerospatiale of France in 1971, following an earlier tie-rod failure that occurred to a foreign registered aircraft. The Bulletin revised the tie-rod design by specifying a high strength steel, with the ends having rolled (as opposed to machine-cut) threads. Additionally, a life of 500 flying hours was imposed. Shortly afterwards, a UK manufacturer offered an alternative design which gained approval by the CAA as a minor modification in 1972. It is this type of rod that was fitted to G-ATKC, and is probably fitted to most of the UK registered Stampes. In comparing the two designs, the following observations are noteworthy.

(i) Most of the original Stampe tie-rods,and the Aerospatiale revision, were of a "waisted" design, i.e. the diameter of the rod across the width of the fuselage is less than the end-diameters (see drawing). The UK-produced rods are of constant diameter. Tensile forces exerted by the wings are distributed between the pair of the rods and the 32 mm diameter steel tube. The larger diameter of the plain rods result in these taking a higher proportion of the loads compared to the waisted design, and consequently induce a higher stress over the threaded area.

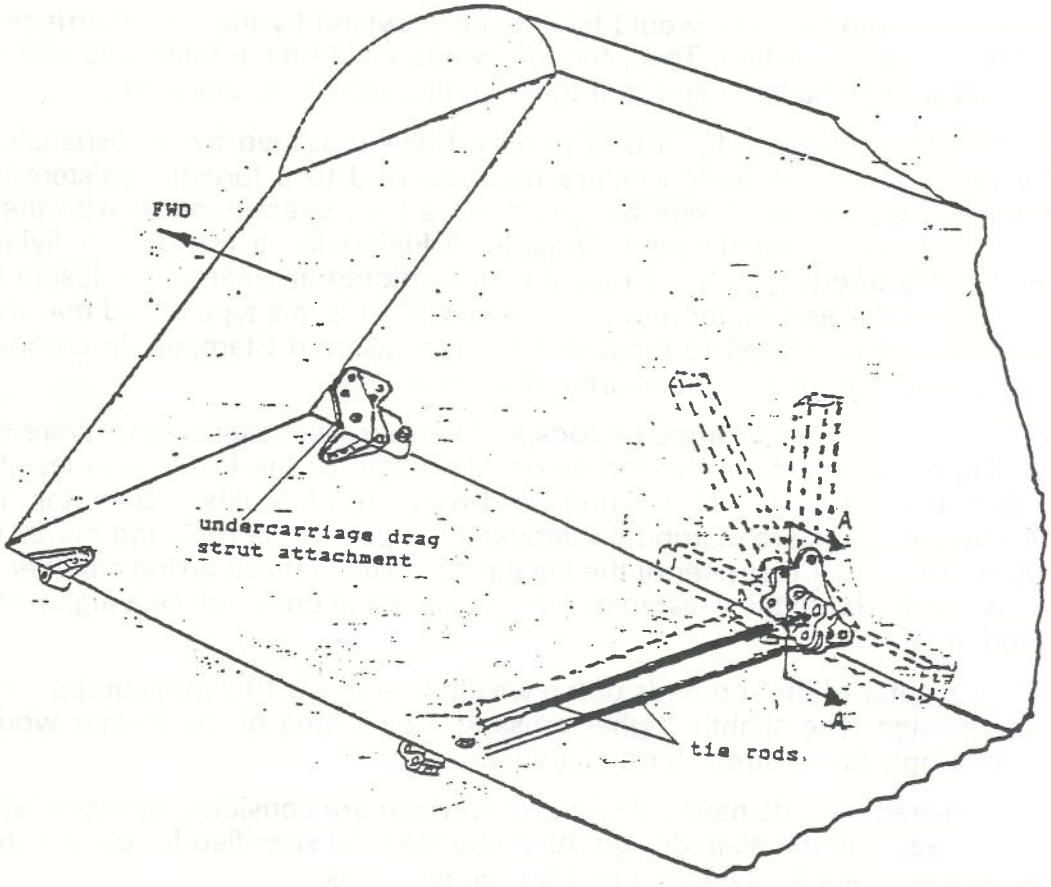
(ii) The diameter of the rod ends of the waisted design is 10.2 mm compared to 10 mm for the plain design. The slightly higher cross sectional area of the former would result in a correspondingly lower stress for a given load.

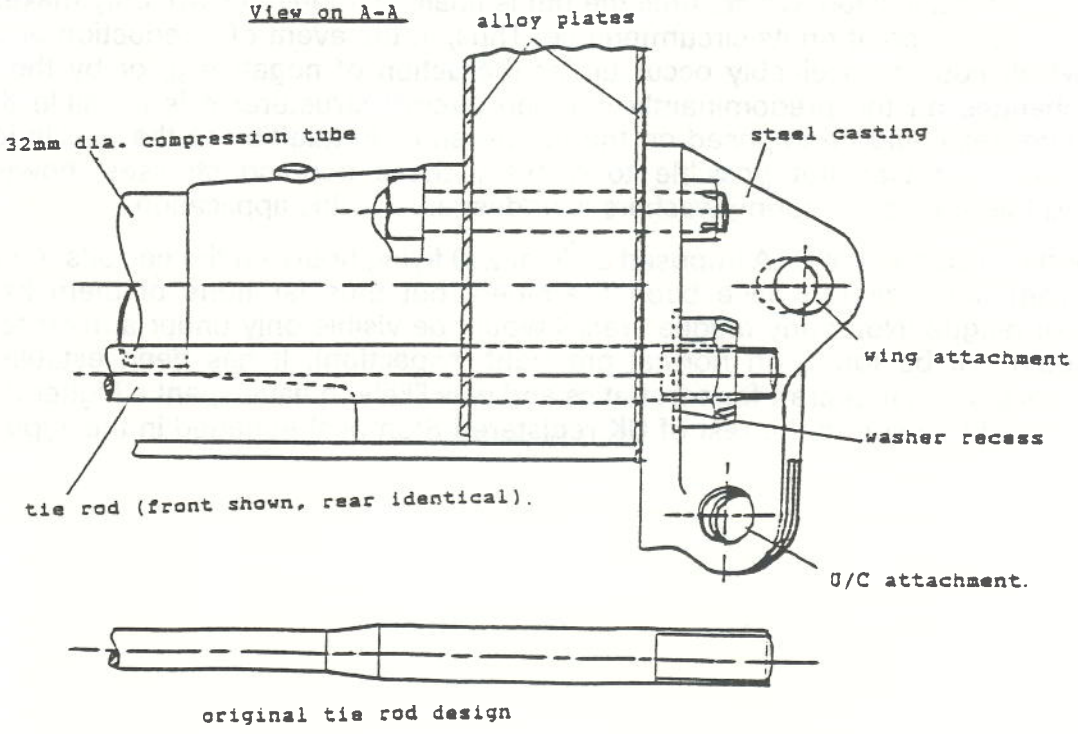
(iii) The waisted tie-rods have rolled threads which are considerably more fatigue-resistant than the threads on the plain design. Also, the material specified for the waisted design is a slightly higher strength steel than that for the plain design.

Finally, it was observed that the tie-rods from G-ATKC had been assembled with spring washers instead of the plain washers called for in the relevant drawings. The spring washer is effectively a helical section, which, until the nut is finally tightened down, only makes contact with the nut at one point on its circumference. Thus, in the event of a reduction of assembly torque (which could conceivably occur under the action of negative g, or by the effect of climatic changes on the predominantly wooden aircraft structure) it is possible that small bending stresses could be imposed on the tie-rod ends, in addition to the tensile loads that normally occur. It was not possible to quantify these bending stresses, however it is considered that the use of spring washers is undesirable in this application.

Following the accident, the CAA imposed a life of 250 flying hours on the tie-rods. A number of tie-rods from other aircraft have been examined, but thus far none of them has shown evidence of fatigue (Note: any fatigue cracks would be visible only under a microscope, and hence would not be found on normal pre-flight inspection). It has been established that G-ATKC was a popular aircraft for aerobatics and was likely to have spent a higher proportion of its life (in comparison to the rest of UK registered Stampes) engaged in this type of flying.

Stampe Wing Attachment Details





original tie rod design