Aircraft Type and Registration:	Stolp Starduster Too, G-BPOD
No & Type of Engines:	1 Lycoming IO-540-C4B5 piston engine
Year of Manufacture:	1975
Date & Time (UTC):	3 October 1993 at about 1350 hrs
Location:	Stancombe Farm, Askerswell, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - Serious Passengers - Fatal
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	26 years
Commander's Flying Experience:	1,165 hrs rotary wing 395 hrs fixed wing (of which 3 were on type) Last 90 days - 87 hrs Last 28 days - 32 hrs
Information Source:	AAIB Field Investigation

History of flight

The aircraft was based at Stancombe Farm. The airstrip was orientated west/east and was 510 metres long with an elevation of 600 feet amsl. The surface of the strip was in very good condition and the grass was short.

On the morning of Sunday, 3 October 1993, the pilot strapped into the rear seat of G-BPOD and a colleague, who was also a qualified pilot, strapped into the front seat. The aircraft took off just before 1130 hrs and flew to Compton Abbas Airfield where it landed at 1145 hrs. The pilot refuelled the aircraft to full and took off again at 1230 hrs. The passenger handled the aircraft in the climb to 6,000 feet at which height both occupants, in turn, performed a series of aerobatic manoeuvres which included loops, barrel rolls and aileron rolls. They then returned to Stancombe Farm and landed.

The pilot then took another passenger for a short flight during which he performed some basic aerobatic manoeuvres. On return to the airstrip, the pilot made an approach to the westerly runway; he used a sideslip technique which allowed him to see the ground from the left side of the cockpit.

However, he was not satisfied with the approach because he was unable to stop the nose of the aircraft yawing to the left; he consequently elected to go-around. He attributed the problem to a crosswind from the left and so, on the next approach, he sideslipped to the right and looked out of the right side of the cockpit. He found this more difficult but a successful landing was accomplished.

The passenger for the third flight was the owner of the airstrip; he was also a qualified pilot. The pilot again occupied the rear seat, and the passenger the front seat. The aircraft took off shortly before 1350 hrs and the pilot held it low to gain airspeed; he then pulled into a steep climb to about 400 feet agl where he levelled off and started to turn right, initially with about 30° of bank. However, the bank then increased rapidly and the aircraft entered a spin to the right from which it did not recover.

Both occupants had five point harnesses, however the passenger was killed instantly as a result of the impact. The pilot was seriously injured; the injuries to his head were caused by contact with his instrument panel which had moved rearwards in the impact.

The two people who had been passengers on the previous flights saw the accident and immediately went to the scene. They realised that the passenger was dead, but that the pilot was still alive and so one went to telephone the emergency services whilst the other made the aircraft safe and comforted the pilot who had been blinded in the accident. As there appeared to be no immediate danger of fire, the rescuer unfastened the pilot's harness but left him in his seat until the emergency services arrived. He noted that the pilot's left leg was stretched fully forward while his right leg was bent (an attitude which he could have adopted to apply full left rudder; the injuries to his left foot/ankle were commensurate with this).

Weather

The weather in the area was fine with good visibility; the surface wind generally was 250°/10 to 15 kt. However, the local wind at the time of the accident was estimated as less than 10 kt. The temperature was 15°C and the dew point 10°C.

Accident site details

The aircraft struck the ground at a point approximately 250 metres north of the western end of the airstrip. The impact area was below the airfield elevation and was hidden from the view of the witnesses.

An assessment of the ground marks which had been made by the aircraft indicated that the impact had been on a track of 016° magnetic, with a dive angle of approximately 70° and with the aircraft inverted. The impact point was marked by a small crater where the engine and propeller had struck the ground.

Immediately adjacent were shallow indentations made by the right wing leading edges. The condition of the left wing leading edges indicated that these had also come into violent contact with the ground, although they had not left impressions as discernible as those made by the right wings. The aircraft had come to rest nearby in an upright attitude on a westerly heading. This suggested that the aircraft had been rotating to the right at the time of impact, such that the angular momentum resulted in the aircraft turning through an additional 90° before it came to rest.

The propeller blade leading edges had sustained damage which indicated that the engine was rotating under power at impact.

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

Examination of wreckage

It was quickly established that although the aircraft had been structurally complete at impact, there had been pre-impact detachment of two out of the three flying wires attaching to the underside of the right hand upper mainplane. The Stolp is of typical biplane construction in that the wings are effectively pin jointed to the fuselage and centre struts, the positive and negative g loads being carried respectively by the 'flying' and 'landing' wires. There are three flying wires on each side of the fuselage, all attaching to the outboard upper mainplanes. The rear-most is attached to the rear spar, while the remaining two are attached to the front and rear faces of the front spar. The flying and landing wires cross over in the interplane area, and they are all lashed to a longitudinally orientated wooden pole, often referred to as an 'acorn'. The flying wire details are shown in Figure 1, and it can be seen that the two forward wires are retained by a single bolt passing through the spar. The spars are of wooden construction, but have steel plates bolted to the front and rear faces at the flying wire attachments. The plates also serve as the interplane strut attachments. The flying and landing wires are stainless steel strips, elliptical in section in order to minimise aerodynamic drag. The ends are terminated with turn barrels and fork end fittings which, at their outboard ends, are attached via nut, bolt and split pins, to channel section brackets. The latter are then bolted to the spars.

Figure 2 shows the two front, right hand side, flying wires in their as-found condition. It was noted that the holes in the channel section brackets bore no evidence of any distress, such as elongation, that could be expected as a result of impact forces with the bolt in position. The same was true of the holes in the associated reinforcing plates, the one attached to the spar front face being shown in Figure 3. Such evidence indicated that the bolt had not been present at the time of impact. Neither the bolt nor its associated nut were recovered, despite a search of the accident site using metal detectors.

Also visible in Figure 3 is an area where the paint had been worn away due to fretting between the plate and the channel section bracket. Similar evidence was found on the underside of the bracket, and indicated relative rotation, about the bolt, between the two components.

The hole in the spar plate (front face) had a raised lip on an arc of its circumference centered on a line whose radial orientation was aligned with the flying wire. This feature was considered likely to have occurred as a result of tension in the front flying wire giving rise to a levering action as the bolt completed its forward migration out of the hole. Additional evidence of the forwards migration of the bolt was provided by a series of marks that conceivably could have been made by the bolt head, on the inner surface of the sheet alloy leading edge.

The front flying wires were removed from the left upper mainplane and the attachment components examined. Before removing the bolt and its associated stiffnut (which required 7.5 ft lbs break-out torque), it was observed that 2 to 3 threads were visible aft of the end of the nut. The faces of the spar plates and the undersides of the channel section brackets showed evidence of rotational fretting, although to a slightly lesser extent than that observed on the right hand side. The bracket attached to the rear face of the spar displayed a bright, uncorroded area around the hole where it had been in contact with the face of the retaining nut. This was in stark contrast to the corresponding bracket from the failure area, which displayed evidence of long term corrosion, although it was possible to discern the contact area of the nut. This led to the conclusion that the nut had been missing from the right hand assembly for some time. Photographs of the brackets are presented in Figure 4.

The bolt removed from the left wing was 2 inches long and $^1/_4$ inch diameter, with a drilled shank to accommodate a split pin. However, the relevant Stolp drawing calls up AN5-20A bolts for the flying wire attachments. The '5' denotes the diameter in sixteenths of an inch; the '20' indicates the bolt length is 2 inches, and the 'A' indicates that the shank should not be drilled for a split pin. Thus the bolts used on G-BPOD were of the correct length, but $^1/_{16}$ inch undersize, and had drilled shanks. It was assumed that the missing nut and bolt were the same as those found on the left wing, as the holes in the spars were both $^1/_4$ inch clearance holes: however, the holes in all the channel section brackets were $^5/_{16}$ inch diameter. The use of drilled bolts with stiffnuts is not generally recommended, as any 'burrs' could cut away the elastic insert (which confers the high-friction properties) within the nut. However, during the removal of the nut from the left side flying wire attachment, it was noted that it retained its high friction characteristics until it was clear of the bolt threads. Stiffnuts are widely used on numerous aircraft types, and no airworthiness problem results through correct usage. However, where there is a risk of rotation in a bolted joint, it is normally safer to utilise a castellated nut and split pin.

Reference to the Stolp Starduster Corporation indicated that $^5/_{16}$ inch diameter bolts have been used since 1968/9. Prior to this, two $^1/_4$ inch bolts were used to attach the channel brackets to each of the spars. The change was made '...to allow rotation of the fitting (*ie the bracket*) to accommodate local flexing or dihedral.'

History of aircraft

The aircraft was constructed in 1975 and by the time it was imported into the United Kingdom in 1989, it had achieved 150 flying hours. The new owner was advised by the CAA and licensed engineers that an extensive rebuild was required before a UK Permit to Fly could be issued. A Norfolk company eventually undertook this task, which took approximately nine months and involved regular visits by pesonnel from the CAA's General Aviation Section based at Gatwick, as well as the regional office at Stansted. The aircraft had been received in a dismantled condition with the flying wires disconnected at the turnbarrels, ie leaving the fork end fittings and the channel section brackets attached to the spar plates. The rebuild did not involve replacing the fabric covering of the aircraft, although the records indicate that it was otherwise comprehensive. In the absence of access panels, knife cuts were made in the fabric to gain access to the structurally critical areas. This included the flying wire attachments, and the person responsible for the rebuild project has stated that apart from visually checking that the nuts were in 'safety', they were not touched. Patches were placed over the knife cuts rather than installing detachable access panels. (Note; it is known that at least one UK registered aircraft, examined as part of this investigation, is fitted with such panels.)

The aircraft was test flown by a CAA pilot in October 1992, during which it was noted that the aircraft flew slightly 'left wing-low' in the cruise, and that the right front flying wire tended to vibrate. This was corrected by tightening the wire and tends to suggest that all flying wires were attached at this time, although it does not necessarily confirm that the nut on the right hand side was in position.

The aircraft was last inspected at an Annual Inspection, in accordance with the Light Aircraft Maintenance Schedule (LAMS) in June 1993, at 168 flying hours. The flying wire attachments were not inspected at that time since it was not a LAMS requirement. Indeed, in the absence of detachable access panels this could not have been achieved other than by cutting holes in the fabric. At the time of the accident, the aircraft had achieved approximately 180 hours.

Probable sequence of events

The sequence of detachment of the two flying wires logically must have progressed from the nut coming off the bolt, the rear channel bracket dropping off the bolt tail, followed by the bolt migrating forward through the spar. When it finally emerged from the hole, the front wire would of course no longer be retained. Whilst the one remaining right flying wire that was attached to the rear spar clearly prevented a complete airborne structural collapse, it is reasonable to assume that there were significant changes in the wing torsional twist and dihedral angle on the right hand side. It is probable that this caused the aircraft to enter the observed spin manoeuvre.

The timescale for the above sequence could not be determined, although it seems improbable that the bolt could have migrated through the spar in a short timescale, such as the duration of one flight. It follows that the rear wire could have been detached for some time. However this need not necessarily have been visible on a walk-round inspection, as the inherent stiffness of the wire material, and the fact that it was linked, via the acorn, to the other flying and landing wires would have tended to retain the wire in position. It is also possible that the rear wire could have remained attached for a time after the nut had fallen away, only becoming detached after partial migration of the bolt, or as a result of negative g or a hard landing. If the aircraft had been flown with only one forward flying wire being loaded, it is probable that small changes in wing twist and dihedral could occur. The fact that the aircraft reportedly flew left wing low in the cruise before the accident may be indicative that such a condition existed.

The reason for the nut detachment could not be determined. It is possible that flying wire vibration, or structural flexing, resulted in the channel bracket unwinding the nut via a 'ratchet' action. However, the corrosion evident around the hole in the bracket indicated that there had been no significant contact with the face of the nut for some time.

Safety Recommendations

As a result of this accident, the following Safety Recommendations have been made to the CAA:

93-70 It is recommended that the CAA should require that all flying and landing wire attachment bolts on UK registered Stolp Starduster aircraft be replaced with correct size bolts and, since limited rotation of the flying wire/spar attachments occurs, castellated nuts and split pins should be required. (Issued 17 January 1994)

93-71 It is recommended that the CAA require all UK registered Stolp Starduster aircraft to be fitted with detachable access panels in appropriate positions on the wings to enable the associated flying and landing wire attachments to be properly inspected for security. (Issued 17 January 1994)

93-72 It is recommended that the LAMS requirement (in Section 7) to 'Remove sufficient detachable panels and covers to inspect the internal structure of ....mainplanes.....' at the 150 hour and annual checks, be amended to include the removal of sufficient fabric to enable adequate inspection of these areas. (Issued 17 January 1994)

NB. This last Safety Recommendation, No 93-72, is similar to one made by AAIB in May 1990 following an accident to a Piper PA-25 Pawnee aircraft, registration G-ATFR, details of which were published in AAIB Bulletin 5/90. The CAA's subsequent response stated an intention to amend the LAMS. However such an amendment was not subsequently implemented by the CAA. Furthermore, the most recent CAA Progress Report 1993 (CAP 625), published in November 1993, stated that it was no longer accepted that it was necessary to amend the LAMS, despite also stating that the associated recommendation was classed as: **'Status - Fully Accepted - Closed'**

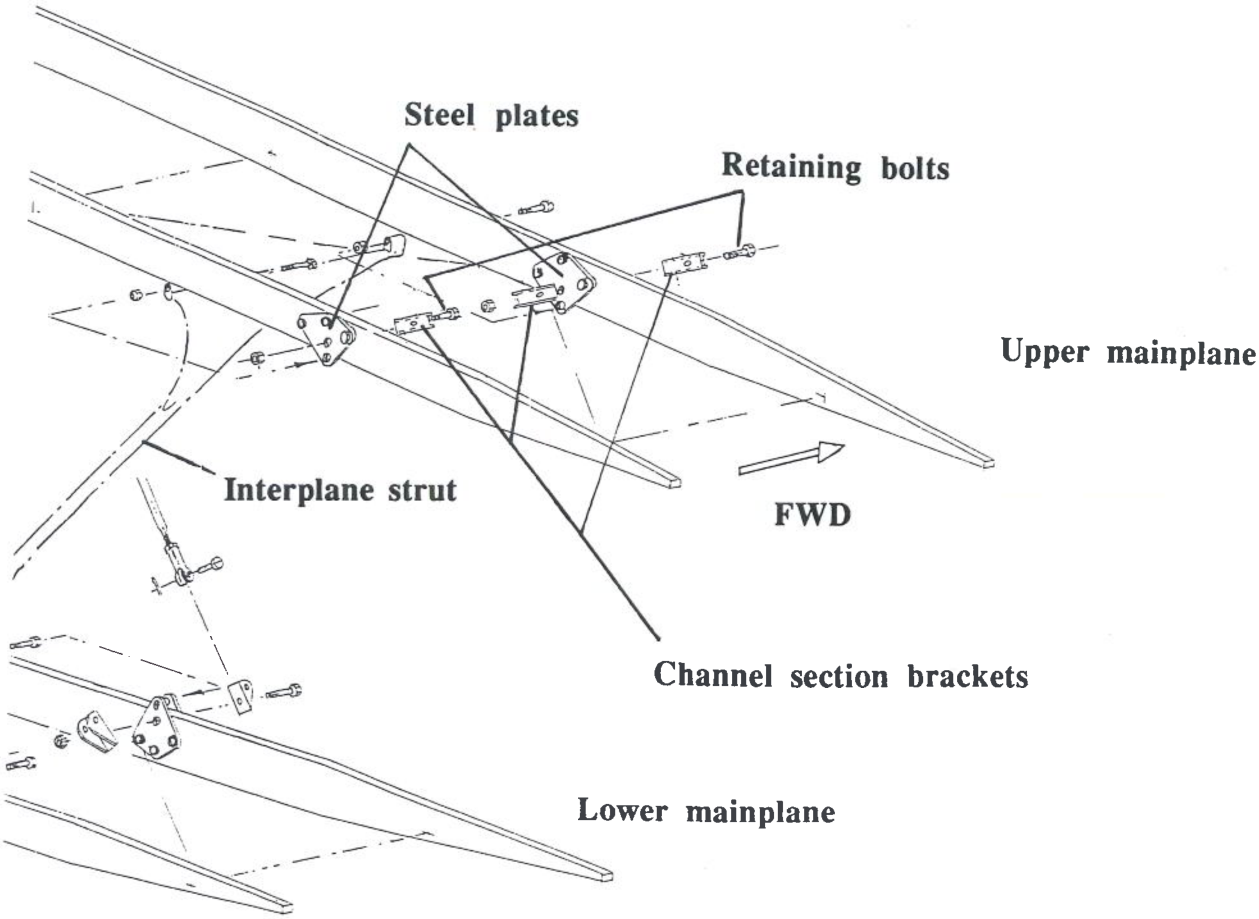


FIGURE 1. Detail from aircraft drawings

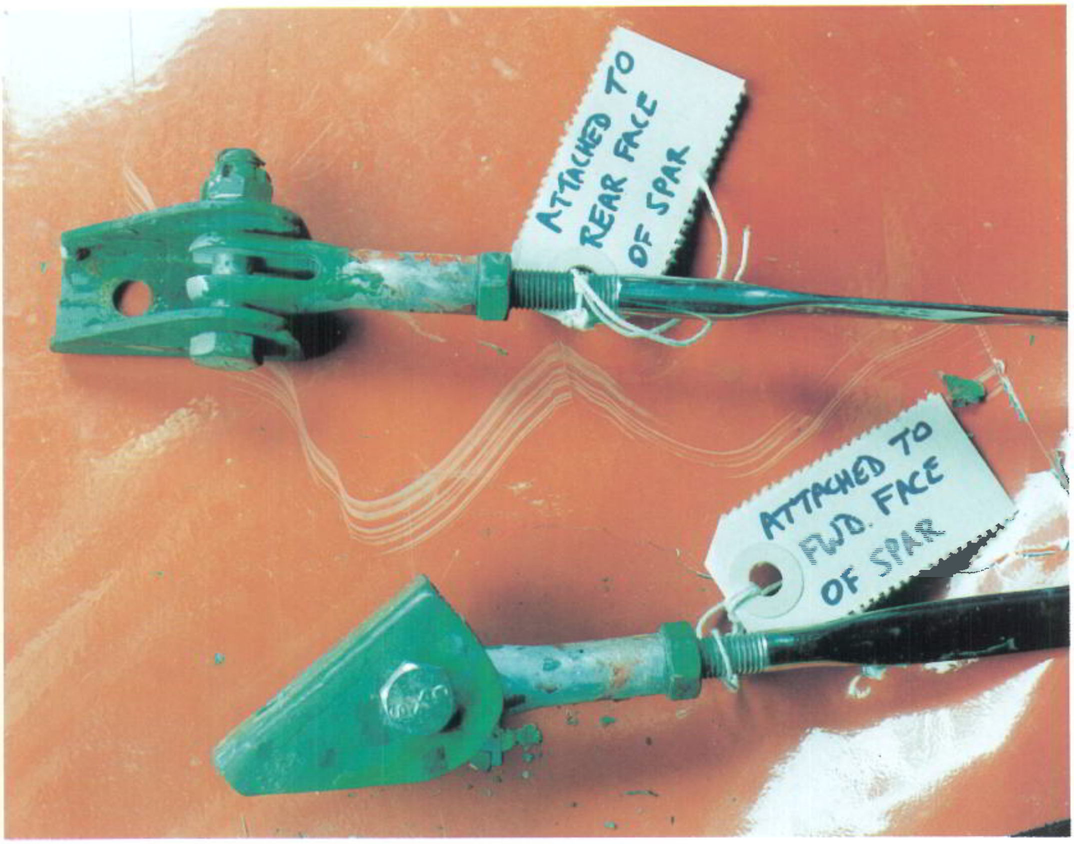


FIGURE 2. Right hand front flying wire attachments; as found

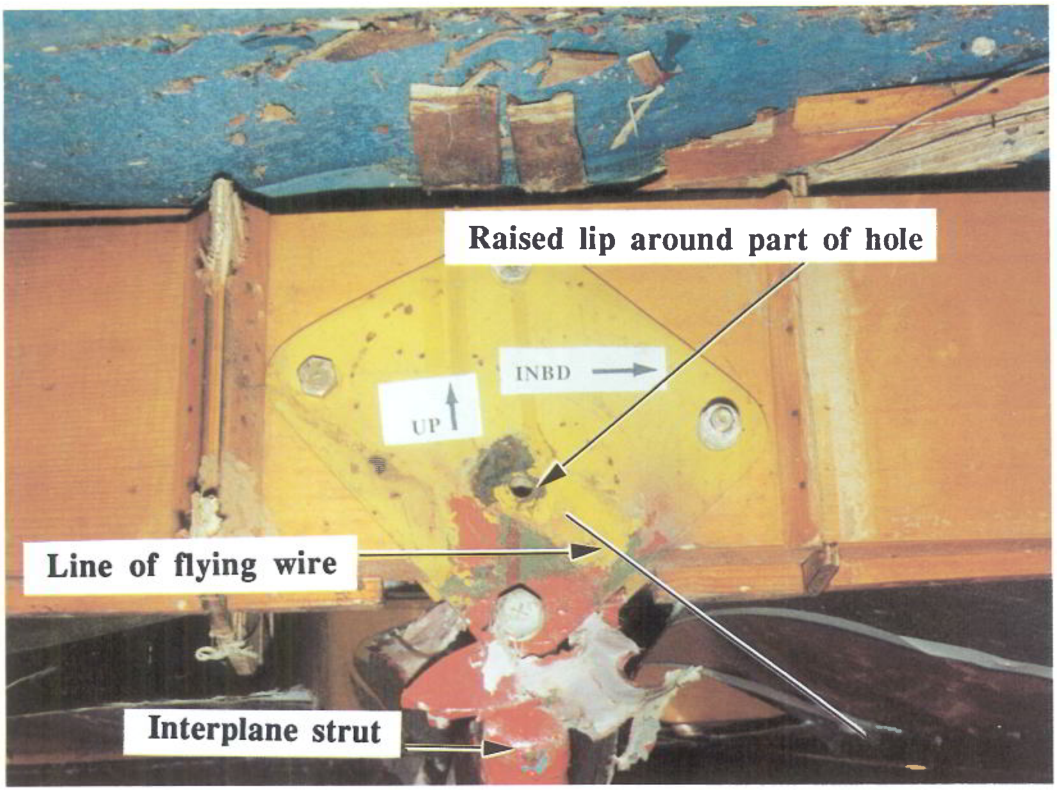
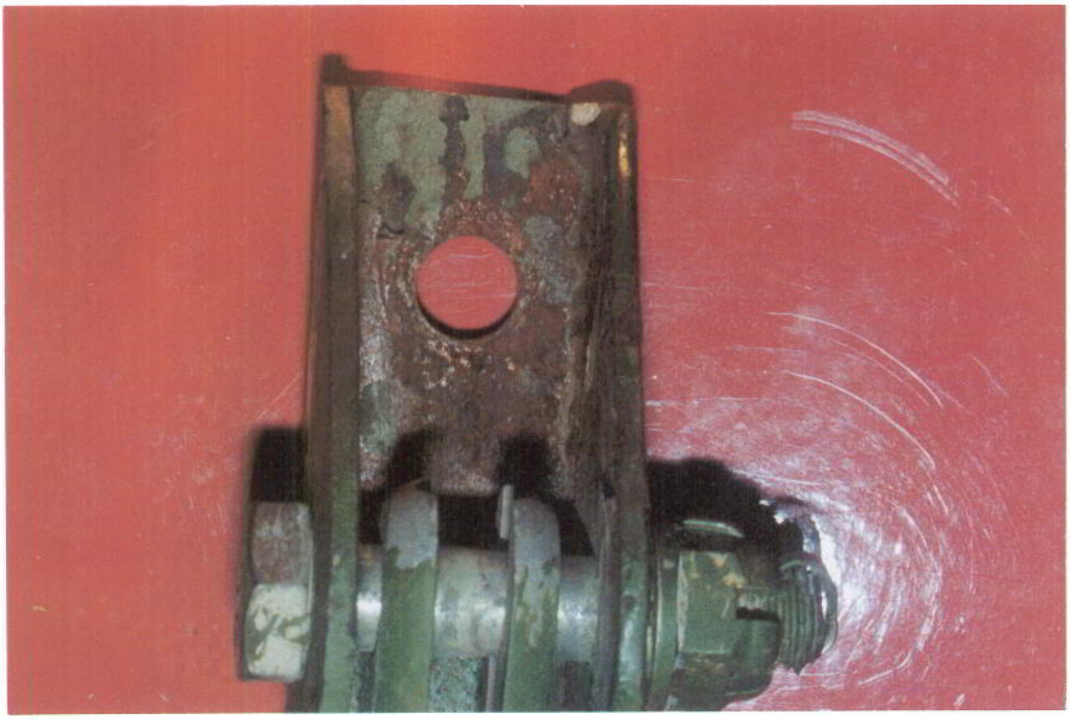


FIGURE 3. View on forward face of front spar of RH upper mainplane. Note area of paint removal due to fretting from channel bracket



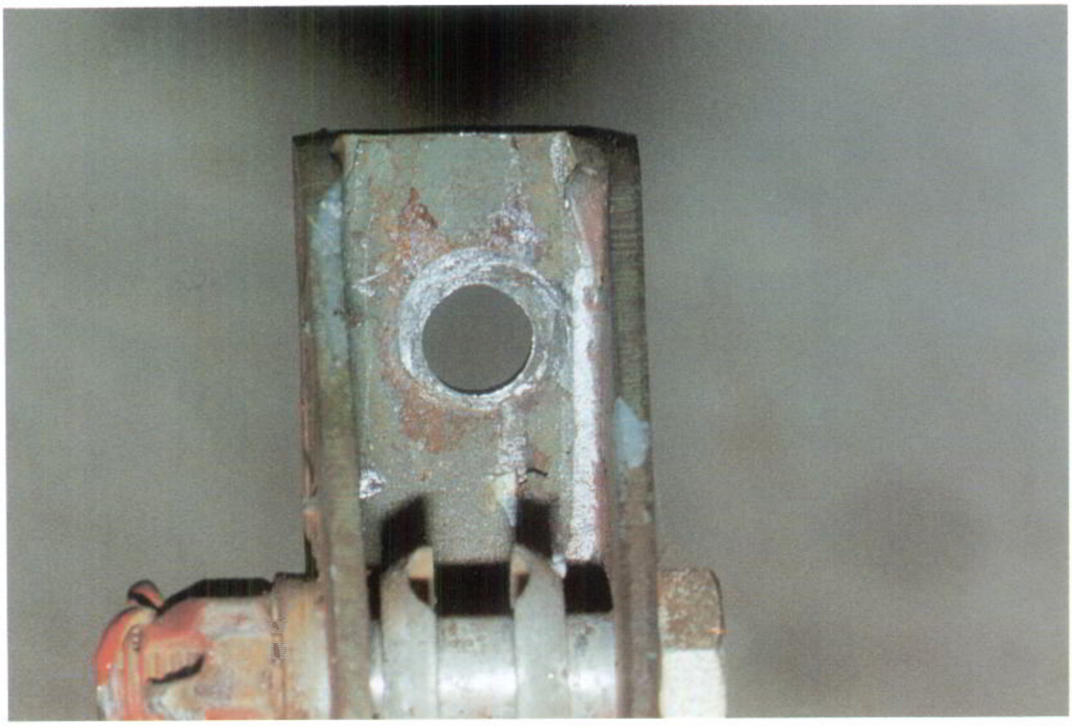


FIGURE 4. Comparison of channel bracket from failed side (top) with item from intact left wing. Contact area of nut face is clearly visible in lower picture. (Note: holes are $^5/_{16}$" dia.)