

**AAIB Bulletin No: 3/96**

**Ref: EW/C95/7/6**

**Category: 1.3**

<b>Aircraft Type and Registration:</b>	Redfern Replica Fokker DR1, G-BEFR	
<b>No &amp; Type of Engines:</b>	1 Lycoming O-360-A4A piston engine	
<b>Year of Manufacture:</b>	1976	
<b>Date &amp; Time (UTC):</b>	20 July 1995 at 1901 hrs	
<b>Location:</b>	Stourhead Gardens, Mere, Wiltshire	
<b>Type of Flight:</b>	Aerial Work (Flying Display)	
<b>Persons on Board:</b>	Crew - 1	Passengers - None
<b>Injuries:</b>	Crew - Fatal	Passengers - N/A
<b>Nature of Damage:</b>	Aircraft Destroyed	
<b>Commander's Licence:</b>	Basic Commercial Pilot's Licence	
<b>Commander's Age:</b>	50 years	
<b>Commander's Flying Experience:</b>	1,776 hours (of which 464 were on type) Last 90 days - 68 hours Last 28 days - 29 hours	
<b>Information Source:</b>	AAIB Field Investigation	

The pilot originally gained his PPL in 1967 after a training course at Plymouth. He was issued with a Basic Commercial Pilots Licence (Restricted to display flying only) in 1990. He purchased and first flew G-BEFR in April 1984, commencing display flying with the aircraft that same month.

In June 1992, the aircraft suffered an engine failure whilst flying in Germany and made a forced landing, during which it sustained major damage. The aircraft was rebuilt and re-engined. It flew again after the rebuild in March 1994. Since that time, the pilot had flown over 48 hours in the aircraft, the majority of this time in display activity.

The pilot had returned to Rendcomb Airfield, Gloucestershire, during the afternoon of 19 July. He had been involved in an aerobatic demonstration visit to Austria, flying a Boeing Stearman biplane aircraft. After a few hours on the ground, he flew G-BEFR to the site at Stourhead for an uneventful evening display, commencing at 1900 hrs. On completion of the display, G-BEFR continued its flight to Dunkeswell Aerodrome, where it remained overnight.

The planned display sequence involved G-BEFR arriving at the display site in order to commence a series of gentle aerobatic manoeuvres. After a few minutes, a formation of three replica SE5a biplanes would arrive in the display area in order to stage a mock dog fight in which they would become the victors. The display organisers had obtained the necessary display approvals from the Civil Aviation Authority for this event and the nominated display line was greater than the minimum allowable distance from the spectator area.

During the morning of 20 July, the pilot returned to Dunkeswell in order to carry out some maintenance work on G-BEFR's exhaust system. This task took several hours to complete. During the course of the day, several hours of sunshine were recorded, and it was noted by witnesses that the pilot did show some external effects of exposure to the sun. The aircraft was refuelled with 49 litres of Avgas from the airfield refuelling facility. The pilot also took an evening meal at the airfield around 1700 hrs. He was dressed casually as the weather remained very warm. The aircraft took off at 1825 hrs bound for the display site, with the intention of continuing the flight to land back at Rendcomb after completion of the display. The pilot had a night-stop kit located in the cockpit stowages, and some tools were contained in a special metal toolbox integral with the seat pan structure.

There were many witnesses to the accident amongst the spectators attending the evening open air event at Stourhead Gardens. Several detailed statements about the aircraft were taken by local police officers and by the AAIB. The sequence of events was formulated from consideration of these descriptions. The aircraft appeared in the vicinity of the site about two minutes early, and made a wide gentle circuit around the area awaiting the 1900 hrs start time. The three SE5a aircraft were holding off a few miles away and were in radio contact with the pilot of G-BEFR on a pre-arranged frequency. The pilot called "running in, one minute" and that was the last transmission heard from the triplane.

As the aircraft commenced the run in for the first manoeuvre, it was seen to have a disturbance in pitch, followed a short time later by a very sharp and uncharacteristic pitch nose down to an almost vertical attitude. During the ensuing dive, the aircraft was observed to either wing rock or complete one or possibly two rotations. The aircraft was banking to the left as it recovered from the dive and disappeared from the view of most spectators as it went behind some trees away from the gathered crowd. A small number of video recordings were obtained from spectators and examined by AAIB. Only one short sequence showed the aircraft in flight just before the impact. The initial pitch down manoeuvre was not seen. The aircraft was seen pulling out from a dive but steeply banked to the left. There was an indication in some video frames that the right aileron was up (roll right) but the left bank angle was maintained until the aircraft disappeared amongst the trees. The images of the aircraft were small and indistinct but they gave no indication of any major structural failure.

The aircraft collided with the top of a tree and spun to the ground, where a large fire engulfed it almost immediately. Two witnesses close to the impact point attempted to rescue the pilot but were prevented from doing so by the intensity of the fire.

A post-mortem report showed that the pilot died as a result of the fire. There was no evidence to suggest that pre-existing disease, alcohol or drugs had any part in the accident.

The weather at the time was good, with a light westerly airstream over the area. The surface wind was from 200° at 10 kt, visibility 25 to 30 km, no low cloud and a temperature of +25°C, dew point +17°C.

### **Engineering examination**

The aircraft crashed in open park land about one third of a mile from the centre of the public event in the gardens. It had descended on to the ground upright but banked to the left and in a nose down attitude with no horizontal speed. There was a trail of small fragments of wreckage and some broken branches between the aircraft and a tree whose top was about 70 feet above the wreckage site. Some of the fragments were found to be from the aircraft's bottom left wing and it was apparent that the aircraft had hit the top of the tree with that wing before descending into the ground. In descending 70 feet after colliding with the tree it had covered a horizontal distance of 160 feet. Although its final descent had been vertical it had substantial forward speed on hitting the tree when its descent angle had been quite shallow. The aircraft had been rotating when it hit the ground and it came to rest facing back towards the tree with which it had collided. Its track direction after hitting the tree, which gives an indication of its final flight direction, was 220°M, a direction which was diagonally away from the main public gathering and 250° to the left of its run-in heading.

The bottom of the fuel tank was punctured in the ground impact. The fire which developed consumed the wooden structure of the wings along with the aircraft's fabric covering; the pilot's controls and instrumentation in the cockpit were all partially consumed. The welded steel tube structure of the fuselage, tail and ailerons survived the fire as did the flying controls and main structural fittings. All the main structural attachments survived and in these and in the structure that remained no pre-crash failure was found apart from the damage to the bottom left wing caused by impact with the tree.

There were two failures in the flying controls. A control rod in the elevator system, which passed underneath the pilot's seat, had broken. The rod end had failed in bending overload when the pilot's seat had collapsed downwards onto it during the ground impact.

The second failure was in the top rudder hinge (Figure 1). The rudder was supported on two hinges each of which was attached to the fuselage by a steel strap. Each steel strap was wrapped around a hinge bearing on the rudder vertical spar and welded to its outer race. The ends of the straps were attached to the sternpost of the fuselage frame by through bolts. Both sides of the strap on the top hinge had fractured. Each fracture path passed through the bolt hole, aft of its centre. The strap and the surfaces of the two fractures were covered by soot and burned paint or fabric. The hinge had failed in a fashion consistent with the ground impact but metallurgical examination showed that both sides of the strap had suffered fatigue cracking.

The fatigue had developed as a result of reverse bending loads, the result of repeated side loads on the rudder in flight. The extent of the pre-existing cracking through both sides of the strap was such that the strap was virtually severed by the fatigue. This makes it likely that the hinge had become detached in the air before the aircraft hit the ground. The right side strap had also cracked further aft, where it was welded to the bearing's outer race, but it had not separated at that location.

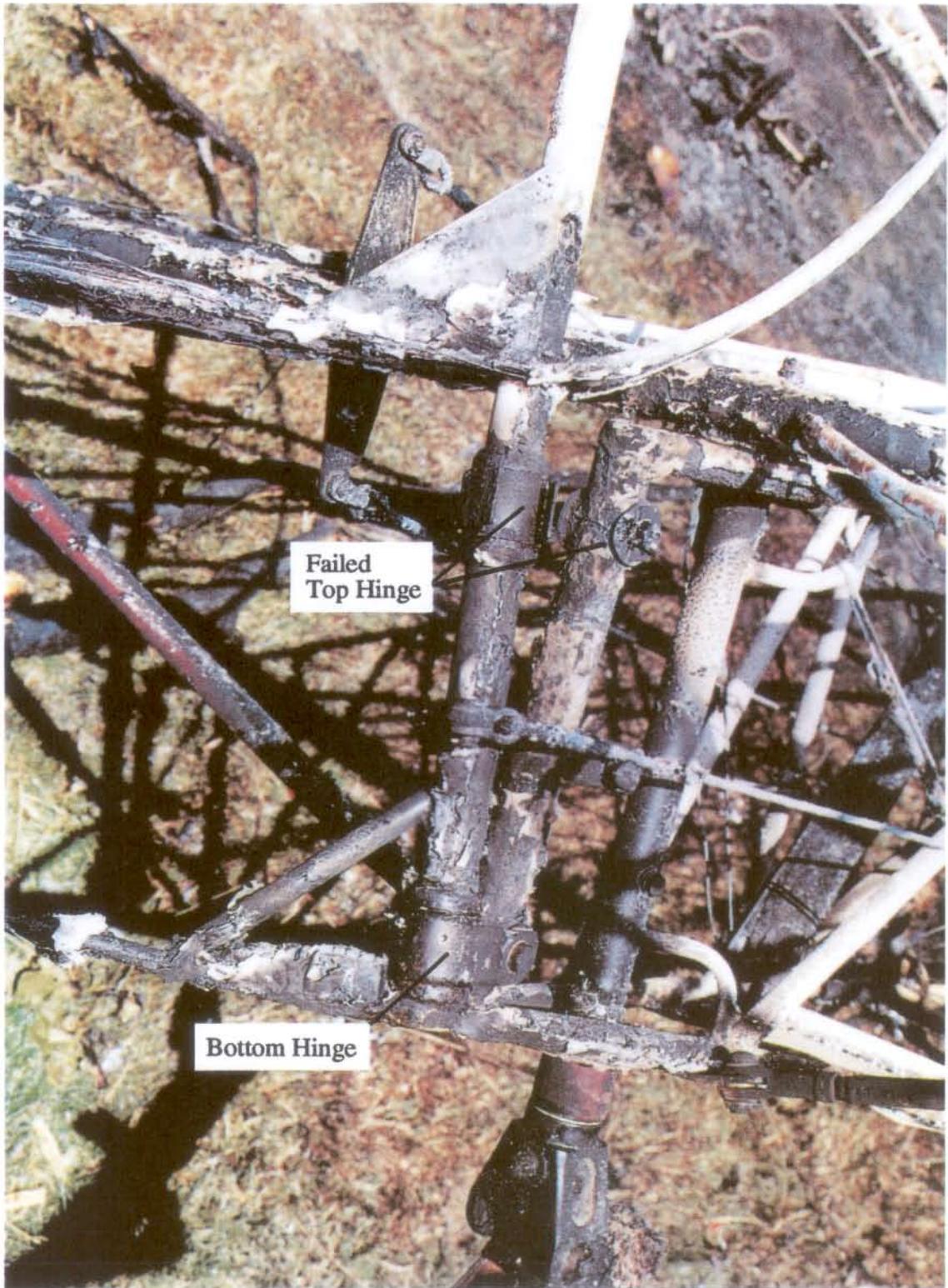
The metallurgical examination revealed that there were two material defects which would have lowered the strap's resistance to the development of fatigue cracks. There was a reduction of the carbon content of the steel in the strap's surface layers and there was some microscopic oxidisation pitting of the surface (from which fatigue cracks had initiated). Both effects could have occurred if the strap had been heated when it was being formed into shape to fit around the hinge. However, the decarburization of the surface could also have been the result of the manufacturing process for the steel sheet from which the strap was made. There was also some corrosion pitting which was the result of slight deterioration with time.

Such a failure of the rudder hinge did not appear to explain fully the eye-witness reports which described the aircraft pitching downwards at the start of the accident sequence with no sign of any yaw. It did not appear likely, because of the amount of clearance available, that the rudder would have fouled the elevator when the top hinge broke. There was no other structural or control failure which could have caused such a pitching manoeuvre.

As a result of some witness statements the possibility of an engine power loss was considered. Both (wooden) propeller blades had broken in the impact, primarily in rearward bending, with no rotational damage. However, the fact that both blades were broken showed that the propeller had rotated at least by half a turn during the ground impact sequence. One tree branch was also found which showed signs of having been cut by the propeller and so there was evidence that the propeller had been rotating at the time of the first tree impact. Even so, the rotational evidence was not strong enough to indicate that the engine was producing power. It is possible that the pilot may have closed the throttle as part of his attempted recovery from the aircraft's steep dive or carried out a crash drill before impact.

The engine was removed and stripped but no mechanical failure was found in it or its accessories. The severe heat and impact damage could have destroyed or obscured evidence and so it remains a possibility there may have been a power loss in flight. A fuel sample from the supply from which G-BEFR had been last refuelled showed a deviation from specification in 'existent gum', which may have come from plasticisers in the fuel hose but this was not thought to be significant.

The aircraft was built in 1976 and operated under a Permit to Fly. Initially, its operation and maintenance were monitored by the CAA but this responsibility was transferred to the Popular Flying Association in 1984. At the time of the accident there was a current Certificate of Validity for the permit and a Flight Release Certificate which had been issued by the Popular Flying Association following an Annual Inspection in April 1995. During the final Annual Inspection (about 20 operating hours before the crash) the rudder hinges had been subjected to a visual inspection for security and wear but had not been dismantled. The rudder hinges fitted to the aircraft at the time of the accident were different to those shown on the Redfern plans. The original hinges had developed cracks and the hinge layout was changed while the aircraft was being re-engined and rebuilt over a two year period following the crash in 1992. The aircraft had completed 54 operating hours since the rebuild. Neither the rebuild report submitted to the PFA nor the other aircraft documents contained any record of the rudder hinge modification or of it having been approved by the PFA.



**Figure 1 - G-BEFR Rudder Hinges**