No: 11/91 **Ref: EW/C91/8/3** **Category: 1c**

Aircraft Type and Registration:	Christen Eagle II, G-BREI
No & Type of Engines:	1 Lycoming AEIO-360-DIA piston engine
Year of Manufacture:	1984
Date & Time (UTC):	17 August 1991 at 1036 hrs
Location:	Ashampstead, near Pangbourne, Berkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - Fatal Passengers - Fatal
Nature of Damage:	Entire aircraft severely damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	Estimated 1,250 hours (of which about 10 were on type)
Information Source:	AAIB Field Investigation

History of the Flight

The Christen Eagle II is similar in performance and configuration to a Pitts Special. It has a high power to weight ratio, two seats in tandem and powerful flight controls. The flight instruments are installed in the front cockpit but, when flown solo, the pilot must occupy the rear seat (Piper Cub style). The engine has inverted oil and fuel systems and the airframe is stressed to +7g and -5g. The aircraft is capable of performing advanced aerobatic manoeuvres in both erect and inverted forms, and it has a vertical penetration (zoom climb) capability of 1500 ft from an entry speed of 156 kt.

The two men on board were the owner, who occupied the front seat, and the pilot in command who was in the rear seat. The owner did not possess a pilot's licence and did not log his flying but it is understood that he had acquired recent flying experience, including aerobatics, in a Chipmunk and the Eagle II; this experience was probably no more than 40 hours in the previous 2 years. The rear seat occupant was an experienced Chipmunk pilot who had converted to the Eagle II in April '91 when the owner purchased the aircraft. He had completed at least 18 flights in G-BREI. Five were with the vendor, one was the collection flight, two were with an instructor, at least seven were solo and five

were with the owner. Most of the accompanied flights were of short duration due to fuel carriage limitations.

On the day of the accident the aircraft had not flown for four weeks. The only known recent maintenance was performed by the pilot and consisted of fitting a replacement battery and an additional leaf in the the tailwheel spring. He re-fuelled the aircraft with 7 Imp gal of AVGAS and then flew solo for about 30 minutes to test the aircraft. On landing he again re-fuelled the aircraft, this time with 4 Imp gals and at about 1010 hrs he was joined by the owner. Together they took off normally from White Waltham at about 1015 hrs and headed west. The aircraft was next seen shortly before the accident in the vicinity of Lower Basildon (14 nm west of White Waltham). Two eye-witnesses close to the accident site reported that when they first saw the aircraft, it was flying straight and level on a westerly heading. Both saw it enter a shallow dive beneath the cloudbase and then pull up into a near-vertical climb. Before reaching the apex of the climb, the aircraft entered the base of a small cloud but only one witness saw it appear above the top of the cloud, still climbing. That witness stated that the engine sounded fine and, at the top of the climb, well above the cloud, the aircraft executed a stall turn. As it recovered to straight and level flight above the cloud, the wings began to rock erratically before the nose dropped slightly and the aircraft rolled to the left. It then rotated four or five times before re-entering the cloud; during those rotations the witness noticed that the aircraft was upside down. When the aircraft re-appeared under the cloud, it was still inverted but rotating in the opposite direction. The eye-witness who had lost sight of the aircraft as it entered cloud stated that it was out of his sight for no more than a few seconds and when it reappeared, it was "cartwheeling" wing-tip over wing-tip. The witness estimated that the aircraft completed at least ten "cartwheels" (below the cloud) during which the rate of rotation reduced as the aircraft descended vertically. It was still rotating when it went out of sight of both witnesses and shortly afterwards they heard or felt the thump of ground impact.

The weather at the time was less than half cover of cumulus and strato-cumulus cloud, base 2500 ft agl with tops up to 6000 ft; the visibility was 30 km and the surface wind was 290°/12 kt. Post-mortem examination of the occupants, who were killed on impact, revealed nothing which was likely to have contributed to the accident.

Examination of the Wreckage

The first impact occurred about 35 feet above the ground and was with trees that were at the edge of a field of linseed crop. This impact was in general between the propeller and main landing gear of the aircraft, and the light foliage and smaller branches of the trees. From the impact marks on the trees and the aircraft, and from evidence at the final impact site on the ground, it was assessed that the aircraft was in excess of 50 degrees pitch nose down, over the vertical axis (ie inverted) and with its wings

very nearly parallel to the line of trees when the initial impact occurred. When the aircraft struck the ground it was 35 degrees over the vertical, wings reasonably level, yawing to the right and rolling to the left. The speed at impact with the ground was approximately 80 knots.

Detailed examination of the aircraft wreckage showed that at impact with the ground all the flying control surfaces were attached and the control systems had not suffered a pre-impact disconnect or restriction. Witness marks at the flying control surfaces and within their control systems indicated that the rudder was deflected about half right, the ailerons were about neutral and the elevator was at the slightly nose pitch down position. It was not possible to assess the elevator trim position. The engine instrumentation and propeller damage indicated that the engine was running and at a low power setting and that the propeller was in fine pitch. There was good evidence of hydraulicing of the fuel tank to a degree that suggested that the tank was 1/4 to 1/3 full at impact (5 to 7 Imp gallons). The fuel selector was found in the ON position and the mixture set at RICH.

Spinning Characteristics

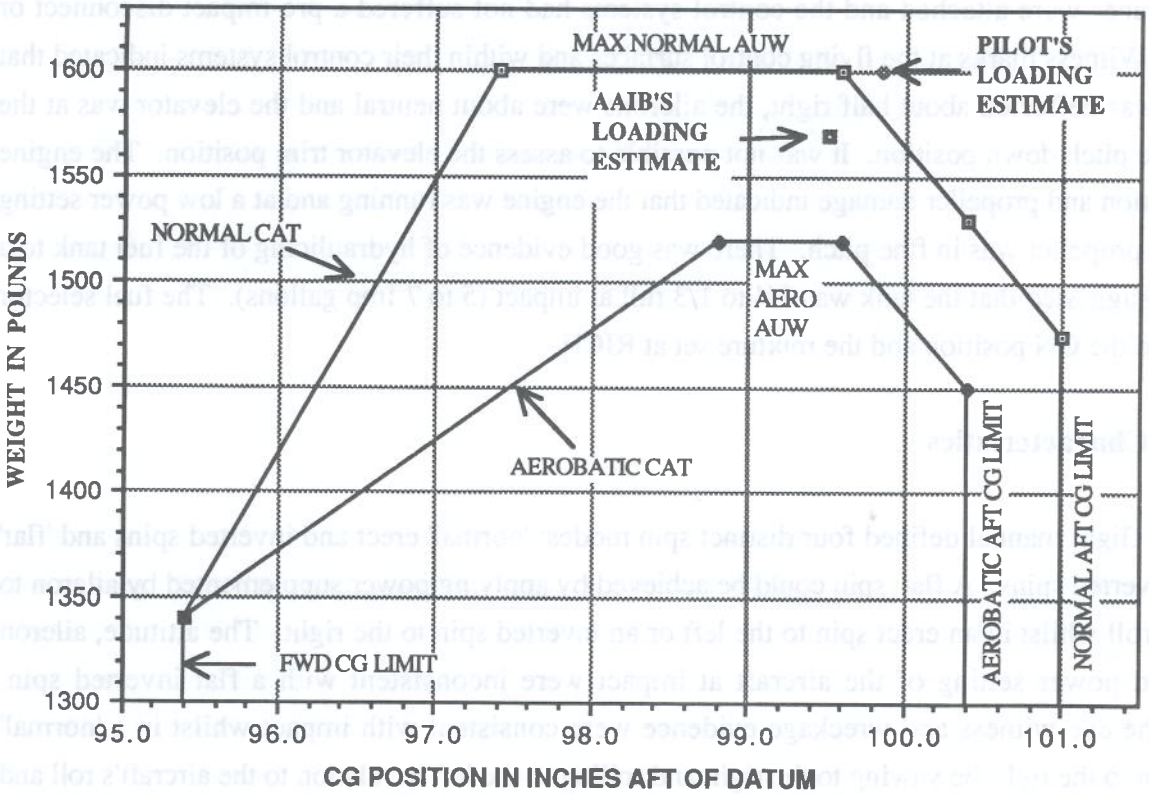
The aircraft flight manual defined four distinct spin modes: 'normal' erect and inverted spins and 'flat' erect and inverted spins. A flat spin could be achieved by applying power supplemented by aileron to oppose the roll whilst in an erect spin to the left or an inverted spin to the right. The attitude, aileron position and power setting of the aircraft at impact were inconsistent with a flat inverted spin. However, the eye witness and wreckage evidence were consistent with impact whilst in a 'normal' inverted spin to the right (ie yawing to the right and rolling to the left in relation to the aircraft's roll and yaw axes). The control positions at the moment of impact were, therefore, pro-spin in that right rudder and forward stick were applied. The flight manual, which was found in the pilot's locker at his home base, contained comprehensive sections on aircraft loading limitations and spin recovery procedures.

Aircraft Loading

The empty weight of the aircraft was established at 1133 lb when it was first issued with a UK permit to fly in July 1989. The pilot's clothed weight was established as 175 lb; the owner's clothed weight was not accurately known but it was likely to have been at least 220 lb and this minimum figure was assumed in post-accident weight and balance calculations. The aircraft had two weight and CG schedules; one for normal category manoeuvres (ie no aerobatics) and another for aerobatics. These schedules were studied by the pilot and markings on the graph within the flight manual left no doubt that he understood how to perform a weight and balance calculation. Indeed, by over-estimating both his own equipped weight and the owner's weight by several pounds, the pilot had concluded that with

just 7 US gal of fuel the aircraft could be flown at maximum AUW but not within either CG envelope. The loading limits together with the AAIB's estimate of the loading at the time of impact are summarised in the diagram below:

CHRISTEN EAGLE II LOADING LIMITS



The diagram shows that the aircraft was probably within the limits for normal manoeuvres but certainly outside the limits for aerobatics. In this respect, the flight manual contained the following relevant text:

WARNING Any particular Christen Eagle II aircraft will recover from any spin type using standard recovery techniques ONLY IF THE AIRCRAFT IS PROPERLY BALANCED. The CG of the aircraft must be within design limits to ensure safe spin recovery. Any aircraft can be dangerously loaded (CG beyond design limits) making spin recovery extremely difficult or impossible.

Spin Recovery Procedures

Where printed in italics, the following text is taken directly from the flight manual:

For inexperienced aerobatic pilots, as well as experienced pilots who are unfamiliar with the spin characteristics of the particular aircraft type, inadvertent and unanticipated spins may produce a

dangerous series of events. Severe disorientation is caused by the spin and by the previous maneuver which produced the spin. The spin type then becomes extremely difficult to identify and therefore produces uncertainty as to the correct recovery procedure.

A primary problem in spin recovery is failure of the pilot to identify the true spin type followed by application of erroneous control forces that hold the aircraft in the spin. For example, if the controls are set for recovery from a normal upright spin when the aircraft is actually in a normal inverted spin, the pilot will unwittingly hold the aircraft in the inverted spin, and recovery will be impossible.

All control inputs for recovery from a spin should be gentle but positive. Violent or extreme pressure on the controls must be avoided. For example, if violent control inputs for recovery from a normal upright spin are made, that is, violent forward stick and violent opposite rudder, the aircraft will recover from the first spin and immediately transition to a normal inverted spin with reversed rotation.

Another serious problem in spin perception will develop during an inverted spin if the pilot attempts to sense yaw direction by looking up through the canopy top because visual ground reference is then made behind the spin axis, leading the pilot to misinterpret yaw direction and use the wrong rudder input for recovery. NEVER LOOK UP THROUGH THE CANOPY TOP DURING A SPIN; always concentrate on determining yaw direction by observing the ground between the engine and the upper wing.

The instrument panel in the front cockpit included a modern turn coordinator which is commonly fitted to aircraft of USA origin. This instrument, being sensitive to roll and yaw rates, may have given unequivocal indications of yaw direction only in an erect spin. In the inverted spin, the instrument would have sensed right yaw and left roll and, therefore, might have given a confusing indication of turn direction to the pilot if he had been able to see it and had chosen to refer to it. A plain turn indicator would have sensed the correct yaw direction in both erect and inverted spins.

The pilot in command was in current spinning practice in the Chipmunk but there was no evidence to indicate that he had received dual instruction in spin recoveries in the Eagle, or inverted spin recoveries in any aircraft type. In its introduction to spinning and spin recovery problems, the flight manual stated *" do not assume that previous flying experience plus limited study will suffice. DUAL INSTRUCTION MUST BE CONSIDERED MANDATORY."*

Two parachutes which were compatible with the aircraft were found in the boot of the pilot's car.