AAIB Bulletin No: 1/96 **Ref: EW/C95/10/8** **Category: 1.3**

Aircraft Type and Registration:	Piper PA-34-200-2 Seneca, G-BADL	
No & Type of Engines:	2 Lycoming IO-360-C1E6 piston engines	
Year of Manufacture:	1972	
Date & Time (UTC):	21 October 1995 at 1318 hrs	
Location:	Edinburgh Airport	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 4
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to nose landing gear operating mechanism, nose fairing, both propellers, engines shock loaded	
Commander's Licence:	Private Pilot's Licence with IMC and Night Ratings	
Commander's Age:	29 years	
Commander's Flying Experience:	209 hours (of which 12 were on type) Last 90 days - 63 hours Last 28 days - 18 hours	
Information Source:	AAIB Field Investigation	

History of the flight

On arrival in the circuit at Edinburgh, after a VMC flight from Blackbushe, the pilot selected the landing gear down but only obtained the green 'down-and-locked' lights for the main gear. Despite recycling the gear switch in the cockpit, operating the emergency lever and manoeuvring the aircraft to increase 'g' loading, the nose gear green light could not be made to illuminate. After using up most of the remaining fuel in a holding area near the Forth road bridge, the pilot flew low past the control tower and the controller confirmed that the main gear was down, but the nose gear was retracted. In a final attempt to extend the nose leg, the gear was recycled several times and during this, the main gear ceased to function but remained in the 'down-and-locked' position. On short final approach, during the subsequent landing onto the grass alongside Runway 25, the pilot shut down the aircraft's electrical systems and, with full flap and windmilling propellers, landed the aircraft at approximately 85 mph into nil wind. After a short roll on the mainwheels, the nose sank to the ground and the aircraft came to a stop. There were no injuries or fire and the pilot and his passengers were able to vacate the aircraft through the normal exits.

Landing gear description

The retractable landing gear on the Seneca is hydraulically operated, power being supplied by a reversible electrically driven pump, complete with integral reservoir, mounted in the nose of the aircraft. The pump is controlled by a selector handle on the instrument panel. As the handle is placed in either the up or down position the pump unit directs fluid through the appropriate lines to each actuator. Fitted in the gear up pressure line from this pump is a pressure switch which breaks the circuit to the motor after the gear has retracted, should the pressure build to 1,800 psi (+/- 1,000 psi). Pressure is trapped in the system between the actuators and a check valve in the pump manifold; this pressure maintains the gear in the fully retracted position. However, as a result of internal seepage, this pressure can decay. Gear up limit microswitches are fitted to the aircraft and wired in parallel such that if any of the three microswitches sense a gear leg not to be in the fully up position, then electrical power is available to the pump motor via the pressure switch. If the system pressure then falls below 1,700 psi, the switch re-makes the circuit and pressure is restored, thus ensuring that the gear remains in the retracted position. In flight, the motor may run intermittently whenever the pressure falls to a value that is insufficient to maintain any of the gears in the fully up position, the rate of cycling of the motor being dependent on the system internal leakage rate.

Upon a gear up selection, the steerable forward retracting nose landing gear is centred by the action of a roller mounted at the end of the steering arm on top of the leg, above its pivot axis, entering a guide channel. This channel is 'open-ended' and its lowermost section is 'joggled' to the right. As the gear retracts, this channel ensures that the wheel correctly aligns with the bay. The retraction system is arranged such that the nose gear is the last of the three to retract, its up motion ceasing as it makes contact with, and operates, the actuating leaf spring of the 'up-limit' microswitch. On G-BADL no physical gear up limit stop was fitted, although later models of aircraft were modified with such a stop to prevent gear overtravel.

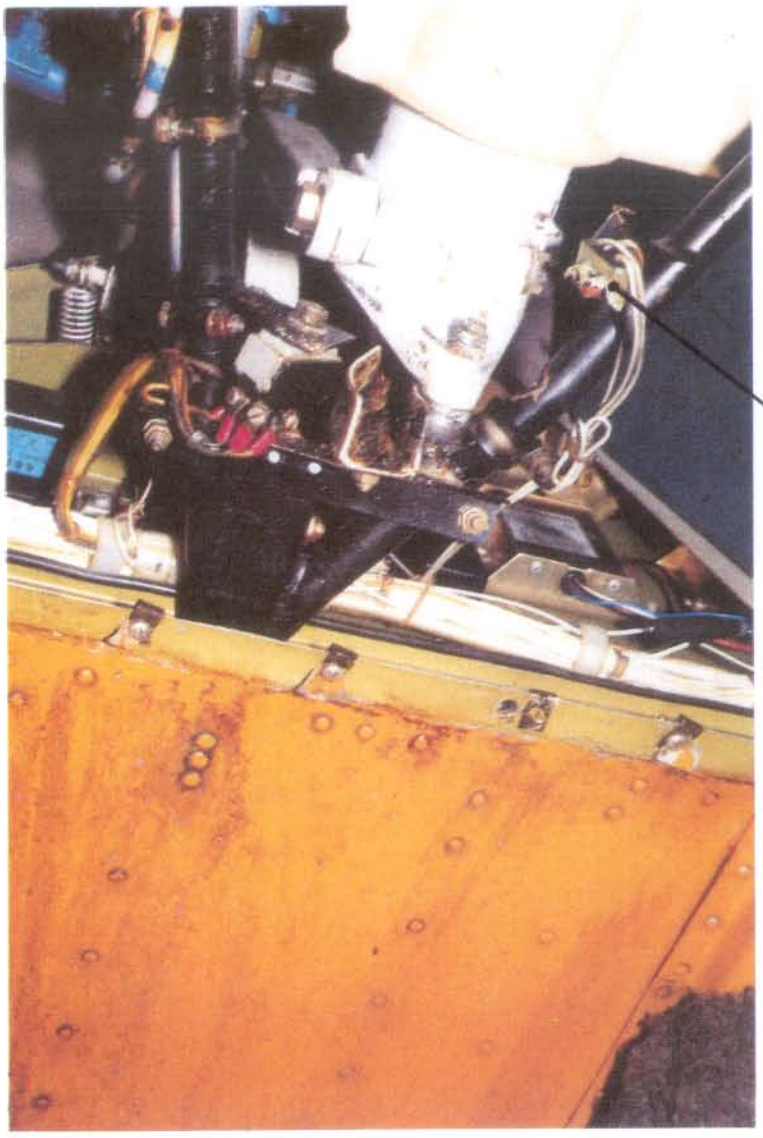
Aircraft examination

After the aircraft had been recovered to a nearby maintenance organisation, the owners carried out a preliminary examination. It was quickly determined that the nose gear had overtravelled and that the centring roller had become free from the end of the guide channel. This had allowed the roller to become misaligned with the channel such that, as the gear was lowered, it travelled for a short distance along the outside of the channel before becoming jammed between the channel and a tubular member of the gear support structure. After the nose of the aircraft had been supported, the roller was

reengaged into the guide channel whereupon, when the gear was manually lowered, it locked into the down position. A photograph showing the roller in the jammed position is shown in Figure 1. Examination of the aircraft by the AAIB, in conjunction with the maintenance organisation, revealed that the gear operating system was serviceable but that damage associated with the nose gear had occurred prior to the landing.

The motor driving the hydraulic pump was unserviceable in that it would not run when power was applied directly. When partially stripped, evidence was revealed of slight overheating and it was evident that both carbon commutator brushes had been completely worn away. Also, the interior of the motor was covered in carbon dust (Figure 2). Both its operating relays were functioned and determined to be serviceable. The up-limit microswitch, and its mounting bracket, had been severely damaged by the nose gear and a failure had occurred to the externally mounted microswitch operating leaf spring. Close examination of this failure, which is arrowed in Figure 3, revealed evidence that a fatigue crack had been present, extending over approximately 75% of the leaf section, and that this crack was located at the start of a sharp bend. The nature of this bend, and the general condition of the spring, suggested that it was pre-existing and had not been caused by the nose gear overtravel and subsequent contact with the switch. It was estimated from the fracture surface that the crack had been growing for some hundreds of cycles. Despite damage to the switch, the gear 'not up' contacts were found in the made position.

The above evidence thus indicated that at some time after takeoff, probably as the gear retracted, the leaf spring on the nose gear up limit switch failed, thereby allowing the nose gear to overtravel, damaging the up-limit microswitch, and becoming jammed. Throughout the flight to Edinburgh, continual cycling of the motor driving the hydraulic pump, and the pressure limiting switch, probably occurred resulting in a motor failure during the attempts to lower the gear prior to landing. The condition of the motor prior to the aincident was not established. Satisfactory retraction checks of the landing gear on this aircraft were carried out during the Annual check in May 1995, and again in July 1995 after both main gear trunnions had been replaced. Since that time, some 18 flights were recorded to have taken place. The most recent maintenance was a 50 hour check, carried out by the owner on 11 October 1995, since when the aircraft had flown four times.



View from below, showing top of nose gear leg in up position but with steering roller jammed against the outside of the guide channel.

Up limit microswitch, damaged by nose gear overtravel.

Figure 1

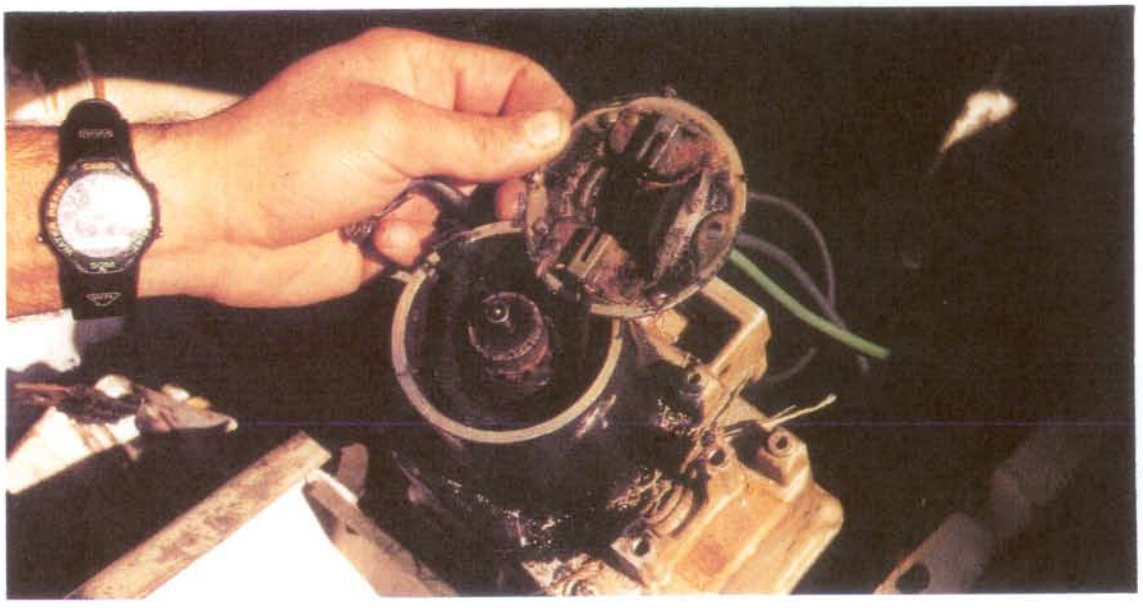
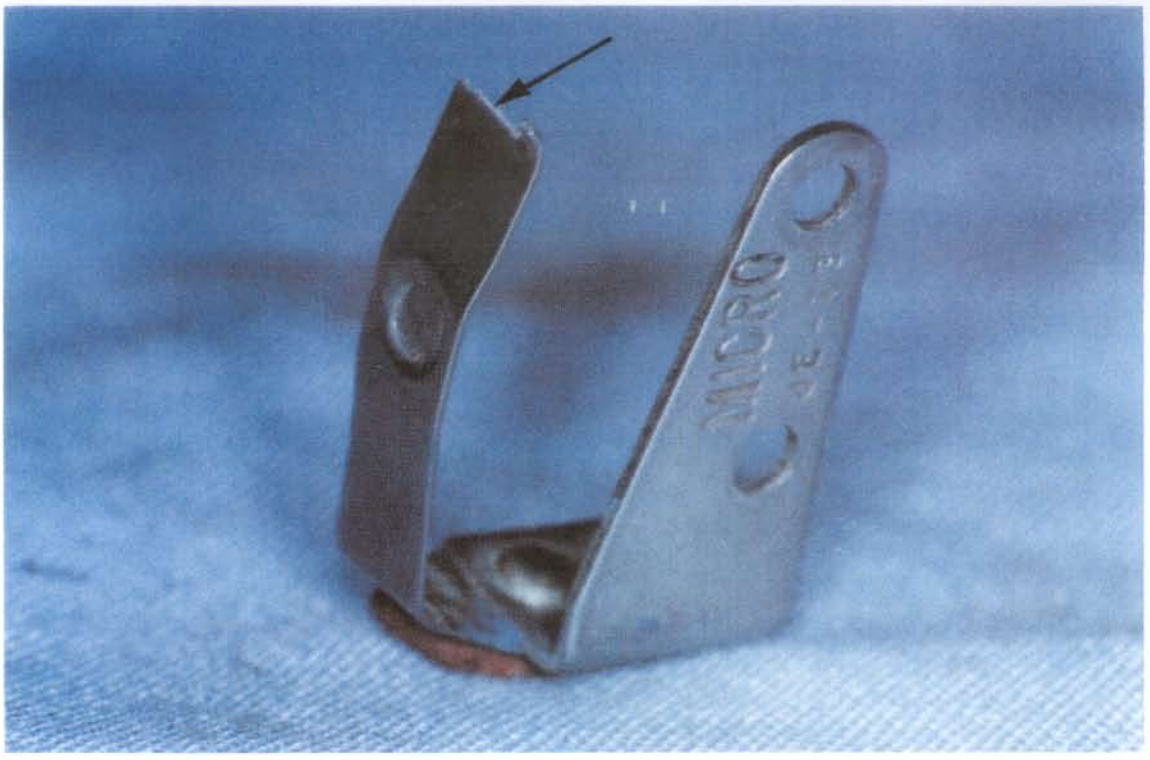
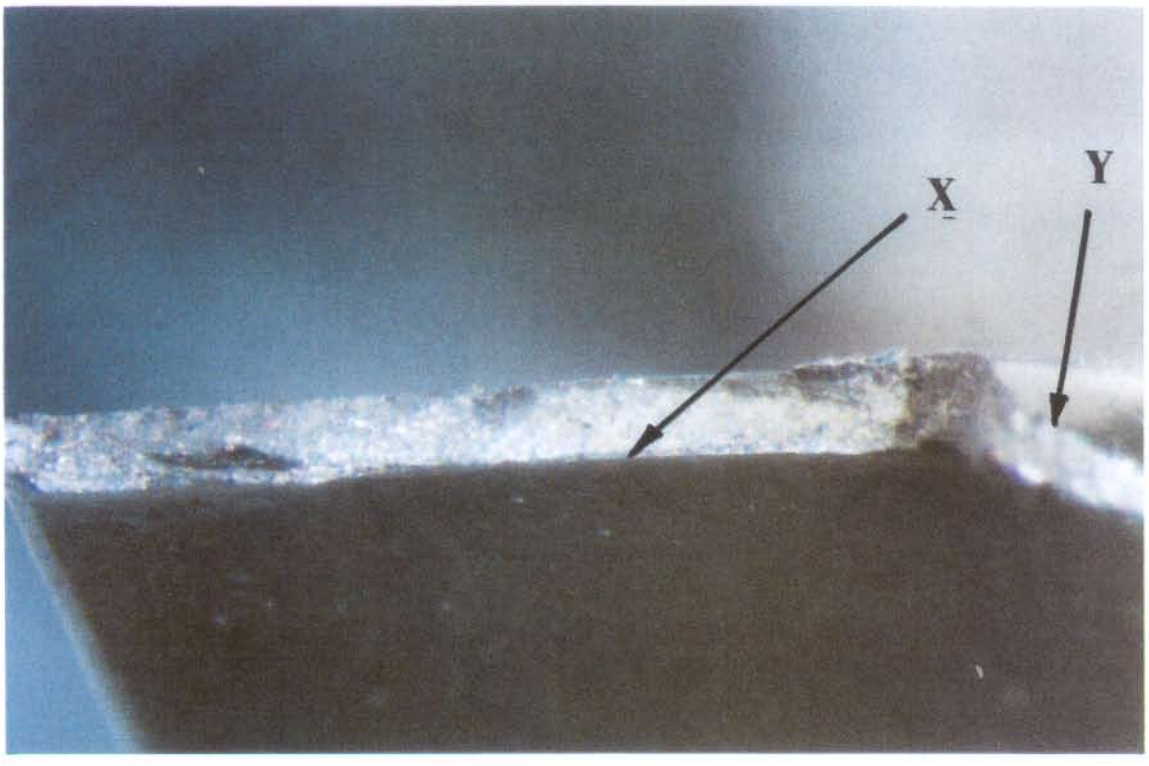


Figure 2

View of hydraulic pump motor showing worn away commutator brushes.



General view of the fractured micro switch operating leaf spring (fracture arrowed).



View on fracture face - initiation region arrowed X. Overload tearing occurred at the right hand end - arrowed Y.

Figure 3