AAIB Bulletin No: 6/95 **Ref: EW/G95/02/13** **Category: 1.2**

Aircraft Type and Registration:	Cessna 310Q, G-AYND
No & Type of Engines:	2 Continental IO-470-VO piston engines
Year of Manufacture:	1970
Date & Time (UTC):	16 February 1995 at 1200 hrs
Location:	Bournemouth (Hurn) Airport
Type of Flight:	Air Test
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to right propeller, landing gear operating mechanism, flaps and gear doors
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	10,400 hours (of which 12 were on type) Last 90 days - 76 hours Last 28 days - 17 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and examination of damaged components by the AAIB

Introduction

The aircraft had recently undergone maintenance in preparation for an application for the renewal of the Certificate of Airworthiness (C of A), at which time operation of the landing gear, both normal and emergency lowering, was tested satisfactorily. It was also operated during this air test prior to the C of A renewal, and the landing gear was reported to have operated satisfactorily using the normal electrically powered system.

History of the flight

The aircraft was crewed with a pilot and observer and it was reported that the air test had proceeded normally until the emergency gear lowering had been attempted. The pilot requested the observer to witness his actions as he applied the related procedure, ie pulling the gear motor circuit breaker, setting

the gear selector to neutral, un-stowing the hand crank and commencing winding. After winding the hand crank the appropriate number of turns the orange gear UP light extinguished, but subsequently only the green nose gear light was seen to illuminate. The pilot then requested the observer to crank the handle, as he was in a slightly better position so to do, but after "some time and effort" the main gear green lights had still not illuminated. The normal system was reinstated, following which an apparently successful retraction was made. However, when subsequently extended using the normal system, again only the green light for the nose gear illuminated. At this point the emergency system was used again, but this time both the pilot and observer formed the opinion that the hand crank had not engaged correctly. When the aircraft was then flown past the control tower and the maintenance personnel responsible for the aircraft all three landing gears appeared to be extended and so the pilot brought the aircraft in to land, shutting down the engines as he entered the flare. However, on touchdown it was soon apparent that the main gear legs were not locked down as the right, left and finally, the nose gear collapsed. Both occupants were uninjured, however, and vacated the aircraft unaided.

Landing gear operating system

Each of the three landing gears on the Cessna 310 type is operated via a series of push-pull rods and bellcranks, all driven from a common gearbox which is located in the fuselage under the pilot's seat. In normal use, the system is operated by an electric motor, driving through a simple reduction gearbox, which rotates a worm drive which is engaged with a quadrant in the main gearbox. A splined shaft, which this quadrant rotates, protrudes from the upper and lower faces of the gearbox, the nose gear being driven by a single lever mounted from this shaft on the lower side, the main gears from a double lever on its upper side. Gear UP and DOWN limit microswitches are attached by adjustable mountings to the upper face of the gearbox and are acted upon by the end fittings of the rods attached to the lever. Provision is made within the gearbox for the worm drive to be operated by hand to extend the landing gear, by means of a stowable crank positioned close to the pilot's seat, the un-stowing of which disengages the drive from the electric motor and engages that from the hand crank.

Examination

The aircraft was examined initially by personnel from the maintenance organisation who established that damage had occurred within the gearbox, but that it was possible for each individual landing gear to be physically locked into the down position. The gear collapse had caused a large overtravel of the

quadrant and levers which, in addition to causing local damage to the airframe, had severely distorted the down limit microswitch mounting, as shown in Figure 1. Subsequent AAIB examination took place after the gearbox had been removed from the aircraft and partially stripped down, and thus it was not possible directly to confirm correct rigging of the system. However, as previously stated, the system had reportedly been checked for satisfactory operation whilst in the hangar and also during the early part of the accident flight.

Damage within the gearbox was identified in three main areas, as shown in Figures 2 and 3.

Firstly, the quadrant overtravel stop, which takes the form of a round steel bar fitted between the upper and lower gearbox surfaces, had completely failed due to overload in a gear travelling down direction and damage was present on the region of the quadrant that abuts the stop. Normally, the down limit microswitch should shut off the electric motor just before the quadrant and stop come into contact and, if the system is correctly rigged, this should co-incide with all three landing gears becoming locked down.

Secondly, the last two teeth of the quadrant had been worn away and the end of the worm drive thread had broken off. Close inspection of this damage suggested that the worm drive thread had been rotating, in a gear down sense, out of engagement but pressed against the end of the quadrant . At this position the quadrant had travelled past the point, by several gear teeth pitches, at which it would have contacted the overtravel stop.

Thirdly, damage was present all around the edge of the gear on the output shaft of the electric motor and at several locations on the sliding gear with which it mates when in normal operation. Closer examination showed the damage to be consistent with the gears coming into mesh with the motor running.

The above physical evidence of damage indicated that at the time of the landing, the worm drive was not in engagement with the gear teeth on the quadrant and that prior to this the overtravel stop had been sheared off by excessive travel of the quadrant. The characteristics of the damage to the worn quadrant teeth also suggested that the electric motor had continued to run after the worm drive had disengaged from the end of the quadrant and that this was its condition when the aircraft touched down. It was also apparent that if the direction of rotation of the worm drive thread was reversed, ie an UP selection

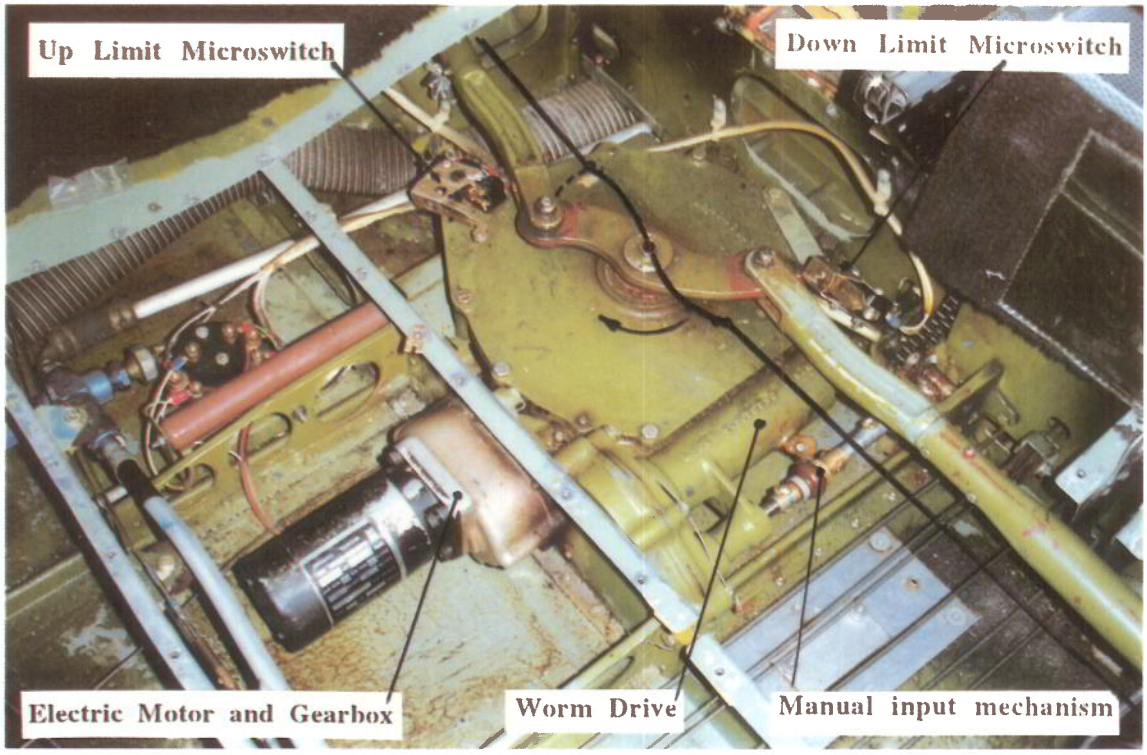
made, then it was quite possible for the worm drive to re-engage with the gear teeth on the quadrant. Any significant overtravel of the system will cause damage to the down limit microswitch and its mounting, with the potential for the switch to fail to operate and allow the motor to run.

Information requested from the manufacturer is reproduced below:

'The electrically driven motor of the main gear landing actuator would have the ability to damage the overtravel stop, if the limit switches were either not functioning or out of rig.

If during a manual 'gear down' extension utilizing the landing gear handcrank the gear was allowed to 'free fall' it may damage the overtravel stop due to inertia from the dropping gear and air loads'.

Examination of the aircraft showed that the down limit microswitch, although damaged in the accident, had been capable of operating and that with the three landing gears down and locked, three green lights illuminated in the cockpit. The design of the system is such that when the gear is down the axis of the push-pull rods should align through the axis of the quadrant's splined shaft, so that there should be little tendency for any loads generated by the landing gear to attempt to rotate the quadrant. This is naturally locked by the inherent nature of the worm drive design, the engagement of the thread at the correct gear down position being 4 to 5 teeth from the end. There was no evidence of distress on either the worm drive thread or the gear teeth at this location. Should the quadrant overtravel, as is indicated in this case, then the effect would be such as to begin the landing gear retraction sequence, the first apparent effect being to unlock the legs and extinguish the green lights in the cockpit.



Landing Gear Gearbox Assembly 'As Found' in Overtravelled State

ie, Quadrant out of engagement with worm drive thread

Normal maximum travel position indicated

Figure 1

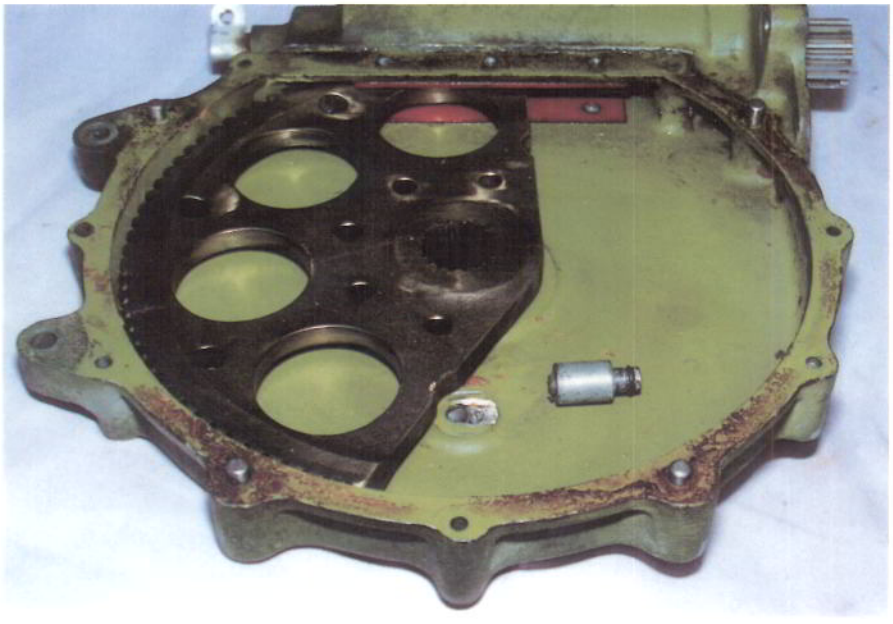
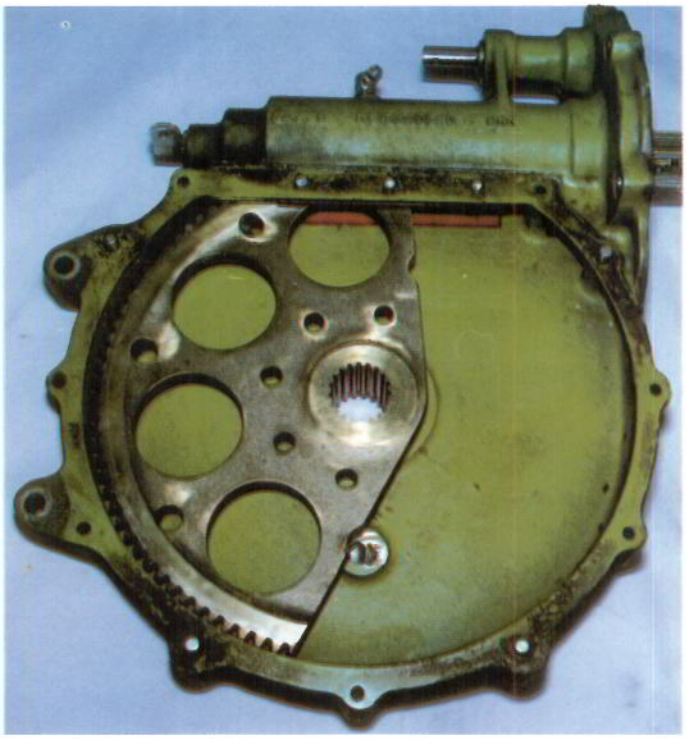
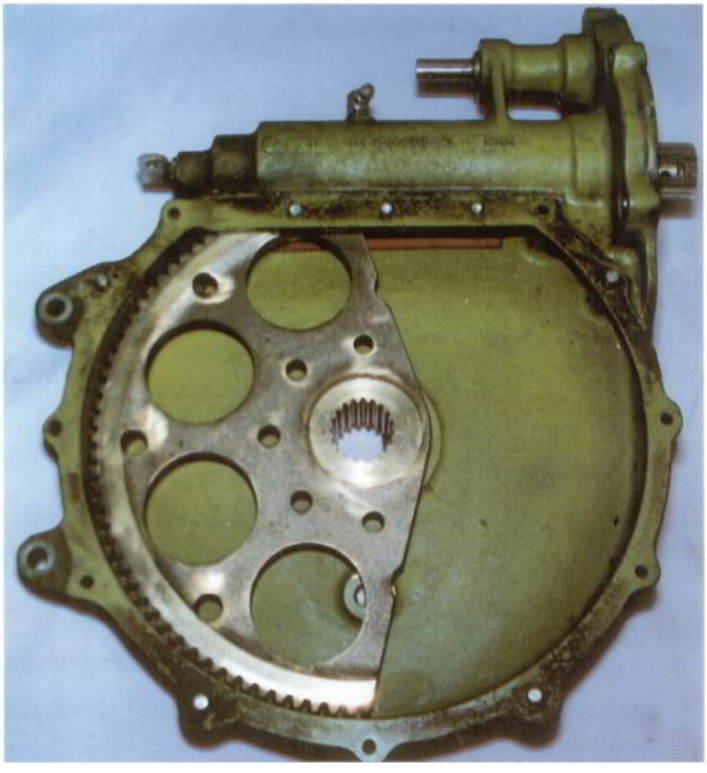


Figure 2

Interior view of main gearbox showing failed overtravel stop and normal 'gear down' position of quadrant when system is stopped by the down limit microswitch



Quadrant position when in contact with the overtravel stop. Worm gear engaged approximately 4 to 5 teeth from end of quadrant.



Quadrant position with gear teeth just out of engagement from worm drive. Wear on last two teeth caused by rotating worm drive shown in lower picture.

Figure 3