Aircraft Type and Registration:	Cessna F177RG Cardinal, G-TOTO
No & Type of Engines:	1 IO-360-A1B6 piston engine
Year of Manufacture:	1971 (Construction number 0049)
Date & Time (UTC):	9 February 2004 at 1205 hrs
Location:	Meppershall Airfield, Shefford, Bedforshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Engine shock loaded. Propeller, nose landing gear doors and exhaust pipe damaged
Commander's Licence:	Private Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	715 hours (of which 215 were on type) Last 90 days - 4 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was flown to a maintenance organisation for the rectification of a landing gear retraction problem. It was flown with the landing gear extended and the electric circuit breaker for the electrical hydraulic pump 'pulled'. The accident flight was uneventful and the landing very smooth. As the aircraft decelerated, its nose dropped and the propeller struck the ground. Post accident rectification revealed defects in all three landing gears. The nose landing gear overcentre downlock was out of adjustment, and the breakout force was minimal. Both main landing gear downlock latch pivot pins had double fatigue and the left one had failed which was the reason for the original landing gear problem.

History of the flight

Twenty three days prior to the accident it was twice noted upon landing gear up selection following takeoff that the landing gear failed to retract fully. In each case following recycling of the landing gear selector the landing gear retracted. Fifteen days prior to the accident it was found that the landing gear would not retract fully and the fault persisted after recycling the landing gear selector. On the day of the accident the aircraft was flown to a maintenance organisation for rectification of the problem with the landing gear extended and the electric circuit breaker for the landing gear's electrical hydraulic pump 'pulled'.

The accident flight to the grass airfield where the maintenance organisation was based was uneventful. Upon arrival at the destination airfield the pilot self-positioned the aircraft on the downwind leg of the circuit pattern, selected 10° of flap, checked that the landing gear green down and locked light was illuminated and reduced the airspeed to 95 mph. After turning the aircraft onto base leg the pilot selected 20° of flap and reduced the airspeed to 90 mph. On final approach the speed was reduced to 75 mph and 30° of flap selected with the landing flare being carried out at 65 mph. The pilot assessed the aircraft's touchdown as very smooth and he held the nose wheel off the ground as long as possible. As the aircraft decelerated, its nose dropped and the propeller struck the ground. As soon as the pilot realised what was happening he pulled the fuel mixture lever to the idle cut off position, switched off the aircraft's electrics, and shut off the fuel. Once the aircraft had come to a halt, the pilot vacated the aircraft via the pilot's door.

The aircraft's history

The aircraft was first registered in the UK in 1971 as G-AZKH. In July 1979 the aircraft was involved in a take-off accident which resulted in damage to the propeller, engine, nose and left main landing gears, and lower fuselage skin (see AAIB Bulletin 10/79). Following repair in May 1982 the aircraft was re-registered G-OADE. In April 1983 when the landing gear was selected down, no landing gear down and locked green light illuminated in the cockpit. The emergency landing gear lowering system was operated (a hydraulic hand pump) but there was still no down and locked indication. A visual examination from the ground indicated that the landing gear was fully extended. A successful landing was carried out whilst operating the hydraulic pump throughout. An engineering examination revealed that the right main landing gear downlock latch pivot pin had failed in fatigue.

In April 1986 the aircraft was involved in a forced landing accident which resulted in damage to the propeller, nose and left main landing gears, and fuselage (see AAIB Bulletin 10/86). In August 1989 the aircraft was re-registered G-TOTO. In 2002 the aircraft had three maintenance checks carried out. During the first of these checks, at 909 airframe hours, the right main landing gear downlock

assembly was replaced. Due to the turnaround in staff and the lack of detail in the paperwork raised by a previous maintenance organisation, which was not located at the accident airfield, the reason for this replacement is not known. During the second check, at 956 airframe hours, the left main landing gear downlock microswitch actuating arm was replaced and during the third check, at 981 airframe hours, the main landing gear was re-rigged.

The landing gear system (Figures 1, 2 & 3)

Retraction and extension of the landing gear is accomplished by a hydraulic system integrated with electrical control and indication circuits. There is one hydraulic actuator for the nose landing gear and one actuator that drives a gear system for both main landing gears. Hydraulic fluid is supplied to the actuators by an electrically-powered reversible pump. The hydraulic reservoir is an integral part of the pump. The electrical pump is controlled by the landing gear selector mounted in the cockpit instrument panel. As the landing gear selector is moved to either the up or down position, the pump directs hydraulic fluid through a power pack control valve assembly to the landing gear actuators. As the hydraulic fluid pressure increases at one side of the actuator pistons, the fluid at the other side of the pistons is directed back through the control valve assembly to the pump. The landing gear extension and retraction pipes serve either as pressure or return lines depending on the rotation of the reversible pump and the position of the landing gear selector in the cockpit. Mechanical overcentre locks provide up and down locks for the nose landing gear. The main landing gears utilise hydraulic pressure for positive uplock and electro-mechanical downlocks. Mounted on the control valve, through which pressurised hydraulic fluid passes during landing gear retraction, is a pressure switch. This pressure switch opens the electrical circuit to the pump solenoid when the main landing gear is fully retracted and the hydraulic pressure has reached approximately 1,500 psi. The pressure switch will hold the electrical circuit open until the hydraulic pressure in the system drops to approximately 1,100 psi at which time the pressure switch closes allowing electrical power to the hydraulic pump. The hydraulic pump will run until the pressure reaches approximately 1,500 psi and the pressure switch opens the electrical circuit. This cycling of the hydraulic pressure maintains the main landing gears in their UP AND LOCKED positions whenever the landing gear selector in the cockpit is in the up position. With the landing gear selector in the down position the pressure switch has no effect on the operation of the hydraulic system. Other valves in the hydraulic system channel fluid to the correct outlets during landing gear extension and retraction, allow return fluid into the reservoir without producing any back pressure and allow for thermal relief. An emergency hand pump, located between the two front seats, is used to extend the landing gear manually in the event of electrical or hydraulic failure.

Mounted in the instrument panel are two landing gear position indicator lights. A single amber light illuminates when the landing gear is up and locked; a single green light illuminates when it is down

and locked. Each of the three landing gears has a downlock microswitch and all three microswitches have to be made to complete the electrical circuit to illuminate the green down and locked light in the cockpit. In addition to illuminating the green indicator light, the making of all three downlock microswitches opens the electrical circuit to the hydraulic pump. Mechanically connected to the main landing gear downlock mechanisms are two unlock solenoids on the back of which are mounted sequence switches. These solenoids are mounted on pivots which allow them to pivot through approximately 7°. One of the functions of the sequence switches is to open the electrical circuit to the hydraulic pump when the main landing gears are in their downlock positions. All three downlock microswitches and the two sequence switches have to be operated before electrical power to the hydraulic pump is switched off during the landing gear extension sequence. When the hydraulic pump switches off, the pressure in the down lines slowly dissipates over a period of time which is dependant upon the seal leak rates in the landing gear actuators. The hydraulic pump will switch on when any of the downlock microswitches or sequence switches break, which, providing the landing gear selector is in the DOWN position, will pressurise the down lines. When a correctly adjusted landing gear is in the DOWN AND LOCKED position no hydraulic pressure is required to maintain it in that condition. During the landing gear retraction sequence, only the sequence switches, the pressure switch and the landing gear selector in the cockpit have a controlling function of the electrical power to the hydraulic pump.

Engineering examination

Initial examination of the aircraft following the accident revealed that: no pre accident major failure of the nose landing gear system had occurred; there was adequate fluid in the hydraulic reservoir; and the electrical circuit breaker for the hydraulic pump was in the 'out' position.

The aircraft underwent extensive repairs before being returned to service. During these repairs a detailed examination of the landing gear system was carried out.

The nose landing gear overcentre downlock was considerably out of adjustment which made the breakout force virtually non-existent. This condition had been present for a period of time. With the aircraft mounted on jacks, and the landing gear and nose leg oleo extended, a number of unsuccessful attempts were made to unlock the nose landing gear.

The downlock latch (part number 2041017-8) pivot pin mounted on the left main landing gear downlock support assembly (2041017-3) was found to have failed due to a double fatigue mechanism which had occurred over a considerable number of cycles. This failure would have disrupted the operation of either or both of the left main landing gear downlock microswitch and its sequence switch. Examination of the right main landing gear downlock mechanism found that its downlock latch pivot pin was at the point of final failure due to an almost identical double fatigue mechanism.

Previous similar failure

Enquires with other Cessna 177RG maintenance organisations found that a similar downlock mechanism failure had occurred to another aircraft in the UK. In 1993 the landing gear on a Cessna 177RG only partially retracted after takeoff. The landing gear selector was recycled but the problem recurred. The landing gear was extended, the down and locked green indication light in the cockpit illuminated and the aircraft returned to its departure airfield where it landed without incident. An engineering examination revealed that one of the main landing gear downlock latch pivot pins had failed in double fatigue.

Manufacturer's landing gear modifications

Over the life of the Cessna 177RG Cardinal aircraft, the manufacturer has upgraded the landing gear extension/retraction system including the downlock mechanisms and has produced three Service Kits, SK177-21A, SK177-22A and SK177-21D which allow owner/operators to modify/upgrade the main landing gear downlock mechanisms on their aircraft. All three of these upgrade options had been carried out on G-TOTO. The latest standard of main landing gear downlock mechanism fitted to all aircraft from serial number 0283 onwards replaces the electrical/mechanical unlock solenoid and sequence switch with a single hydraulic unit and removes the downlock latch pivot pin from the original design. This latest standard of main landing gear downlock mechanism has been shown to be relatively trouble free compared to the original electrical/mechanical system. There is no Service Kit available to modify/upgrade aircraft to this latest standard.

Analysis

It is probable that the initial problem that G-TOTO encountered when the landing gear would only partially retract was the result of the left main landing gear downlock latch pivot pin failure not allowing the unlock solenoid to pivot correctly. This in turn did not allow the sequence switch to close the electrical circuit to the electric hydraulic pump and consequently, it did not allow the hydraulic part of the retraction sequence to function. The main landing gears became mechanically unlocked which allowed them to move partially rearwards towards their retracted positions due to their weight and aerodynamic drag. In the landing gear partially retracted position, the downlock microswitches would have been broken allowing the landing gear extension sequence to function normally. When the landing gear was extended it was possible that the geometry of the main landing gear mechanical downlock mechanism, with the left main landing gear downlock latch pivot pin having failed, allowed the downlock microswitch to close and, providing that the other two downlock microswitches were also closed, would give a landing gear down and locked indication in the cockpit.

The nose landing gear collapse was caused by a number of factors. The landing gear overcentre downlock was out of adjustment and the breakout force almost non-existent. There would have been no residual hydraulic pressure in the down lines and, due to the circuit breaker for the electrical hydraulic pump having been 'pulled' prior to the flight, the hydraulic pump did not switch on to pressurise the down lines as the nose landing gear downlock microswitch broke. If there had been hydraulic pressure in the down lines it would have resisted the landing gear's collapse although a correctly adjusted landing gear in the DOWN AND LOCKED position does not require hydraulic pressure to maintain it in that condition. However, the accident airfield has a grass runway which in some areas is undulating. These undulations may have produced oscillations in the nose landing gear oleo which caused the out of adjustment mechanical overcentre downlock to 'flick' into the unlock position.

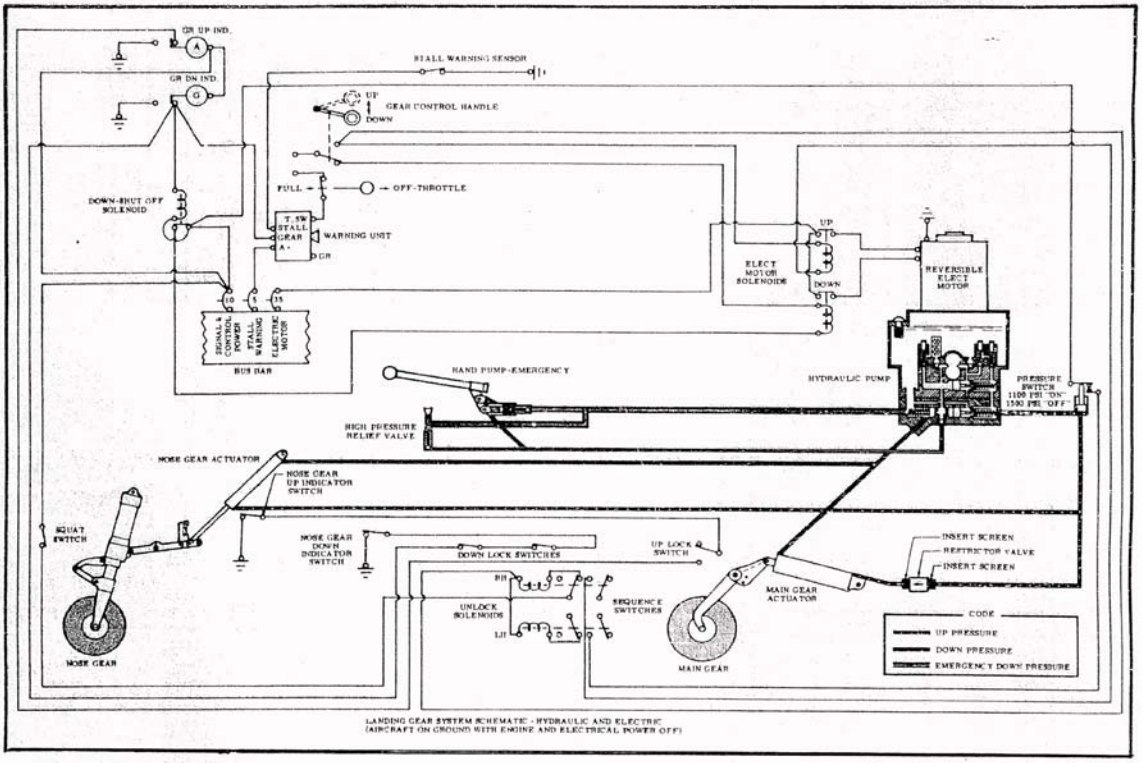
The fatigue of the downlock latch pivot pins had occurred over a period of time. It is likely that this fatigue had been the result of either incorrect rigging of the main landing gears or the rigging having gone out of adjustment in-service, by for example a heavy landing, allowing excessive loads to be placed on the pivot pins.

Safety Recommendation 2005-032

It was recommended to the Cessna Aircraft Company that the Cessna 177RG Maintenance/Service documentation should specify to owners, operators and maintainers that whenever a mechanical failure is found in any part of a main landing gear assembly, the corresponding main landing gear assembly should be examined for a potential similar failure.

Safety Recommendation 2005-056

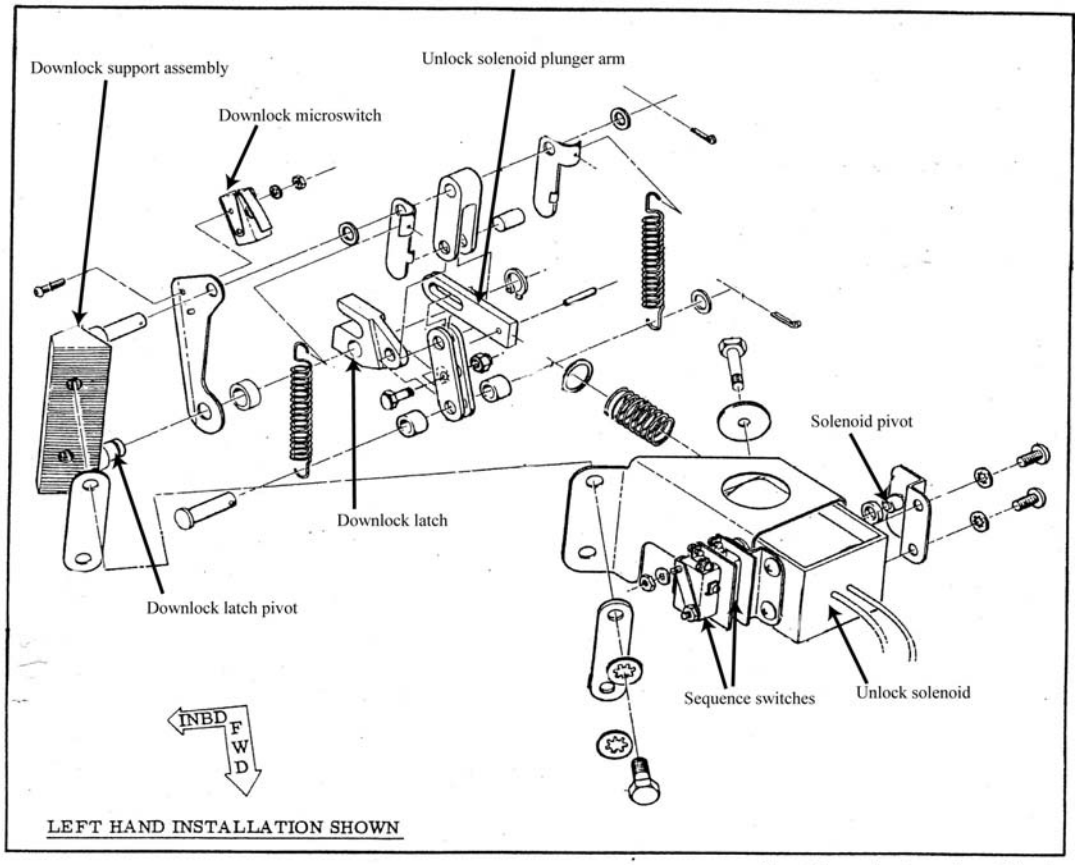
It was recommended to the Cessna Aircraft Company that consideration be given to making available to owners and operators of Cessna 177RG Cardinal aircraft a Service Kit that will enable them to upgrade their aircraft's landing gear extension/retraction system to the standard fitted to aircraft serial number 0283 onwards.



A copy of an aircraft manuafacturer's diagram

Figure 1

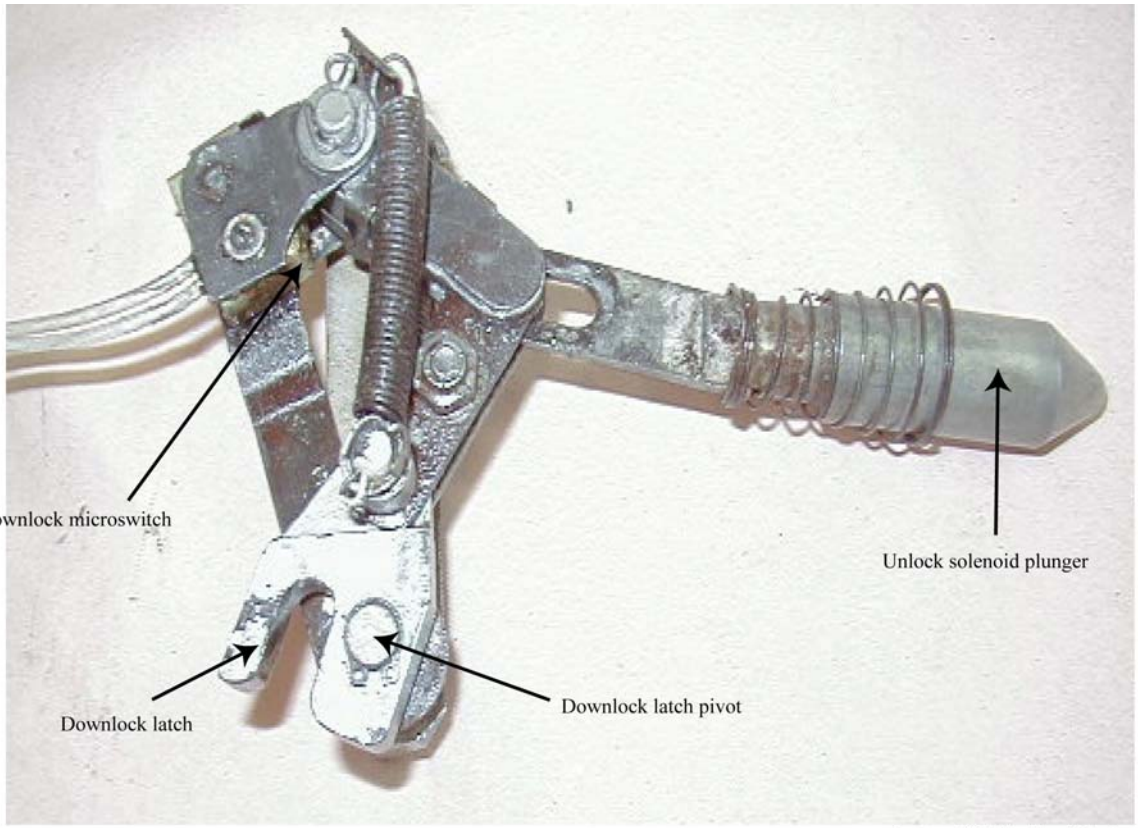
Diagram of the landing gear hydraulic and electrical system



Adapted from an aircraft manufacturer's drawing

Figure 2

Diagram of the left main landing gear downlock mechanism



Courtesy of Brinkley Aircraft Services

Figure 3

Photograph of part of the main landing gear downlock mechanism