AAIB Bulletin No: 5/99 **Ref: EW/C98/12/04** **Category: 1.2**

Aircraft Type and Registration:	Piper PA-23-250, G-BATX
No & Type of Engines:	2 Lycoming IO-540-C4B5 piston engines
Year of Manufacture:	1972
Date & Time (UTC):	18 December 1998 at 1750 hrs
Location:	Shoreham Airport, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	Left propeller damaged in accident, right wing damaged during subsequent inadvertent right main leg retraction during salvage operation
Commander's Licence:	Private Pilot's Licence with IMC Rating
Commander's Age:	40 years
Commander's Flying Experience:	600 hours (of which 200 were on type) Last 90 days - 3 hours Last 28 days - 1 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, information supplied by airport management and by maintenance company, examination and testing of aircraft and components carried out under AAIB supervision

The pilot reported that he had carried out a series of low approaches and go-arounds followed by a normal approach to land. Pre-landing checks carried out and landing clearance was obtained. ATC requested and received confirmation of '3 greens'. Touchdown was normal and the aircraft had slowed considerably before the left main landing gear leg began to collapse slowly. The pilot shutdown both engines and reported the problem to ATC. He then shut off electrical services and fuel before ordering the passengers to evacuate the aircraft.

During subsequent operations to remove the aircraft from the runway, carried out by the airport management and the fire service, an air bag was inflated under the left wing, lifting the partly retracted leg clear of the ground. It was then noted that the other landing gears were geometrically locked. An

attempt was made to manually move the left leg into the fully extended position. This resulted in the right main leg retracting, allowing that side of the aircraft to fall onto the ground.

Once the aircraft had been moved to a hangar and jacked, an examination of the landing gear was carried out, followed by functional checks. No mechanical failure of the landing gear system was found and no external leakage of fluid was visible. Functional testing utilising a hydraulic ground power unit was carried out in the presence of the AAIB; all operations appeared to function correctly.

It was noted that a similar landing incident had occurred to this aircraft in 1996, although on that occasion the right main leg was affected. No conclusive cause was established. A study of the documentation generated during the repair process indicated that, although extensive replacement of worn pivot bolts throughout the system took place, the only rectification of hydraulic components noted was the replacement of seals in the anti-retraction valve.

In view of the nature of the most recent accident and the design of the aircraft system, it was concluded that the only way the leg could have become unlocked was for hydraulic pressure to have been supplied to the landing gear retraction lines. It was accordingly decided to remove the main hydraulic power pack and rig test the unit.

General description of system

This version of the PA23 type utilises a single fixed displacement hydraulic pump, driven by the No 1 engine, supplying a flow of fluid to the power pack positioned ahead of the instrument panel. The landing gear and the flaps are controlled by individual levers, operating longitudinally positioned spools within the power pack. Once either lever is moved from the neutral position it is held in the selected position by a spring and detent arrangement.

Movement of either spool causes an appropriate poppet valve to be opened, thereby supplying pump pressure from the power pack to the required hydraulic line to raise or lower the landing gear or flaps as appropriate to the selection. At the same time another poppet valve on the relevant return line is opened by the spool, thus allowing return fluid to flow via the power pack to the reservoir and hence to the unpressurised side of the pump.

Following a landing gear down selection, once the gear is fully extended, pressure within the down lines continues to rise until a plunger, part of the selector detent assembly, is forced up against the spring, releasing the spool and allowing the appropriate return spring to drive the selector to the neutral position. After the spool and lever return to neutral, the pressure in the down line falls to

approximately 500 psi; this residual pressure ensuring that the mechanical down-lock remains firmly engaged.
Retraction of the gear occurs in a similar way, fluid flowing into the retract line and out of the extension line, the spool and lever returning to neutral position once retraction is complete. The flap operating system performs both lowering and raising functions in the same fashion.

Component testing

Testing of the power pack took place under AAIB supervision and was carried out using a general-purpose hydraulic test rig with the flap and landing-gear extend and retract lines connected to the appropriate ports of slave flap and landing gear actuators respectively. Pressure gauges were positioned on the extend and retract lines of both systems. The testing was carried out largely in accordance with the requirements laid down in the PA 23 Maintenance Manual.

On selecting landing-gear down, the hydraulic pressure in the extend line rose to the correct threshold figure once extension was complete, but fell quite rapidly to zero after the selector and spool returned to neutral, rather than retaining the residual 500 psi as the specification in the manual required. If flap operation was then selected, either up or down, movement was slow and, once full flap deflection occurred, pressure rose in both the up and down lines of the landing-gear system, the up line pressure leading that in the down line. This indicated that significant internal leakage was taking place inside the power pack. Insufficient pressure was developed in the flap extend line to cause the flap lever and spool to return to neutral.

General conclusions

Although the precise sequence of events during the accident is not clear, the system was capable of correctly lowering and locking the gear. As, however, the correct residual pressure did not thereafter remain in the down line, once the extend cycle was complete, the continued engagement of the down-lock would not have been assisted by the hydraulic system. The lack of such line pressure means that any fluid leaking into and pressurising the retract line of the landing gear from within the power pack would readily cause movement of the downlock to an unsafe position.

In the test, although both landing gear lines began to pressurise during flap operation, the pressure in the retract line rose slightly faster than that in the extend line. Whether the leg unlocked just before touchdown or whilst the aircraft was on the ground roll is not known. Once the leg was unlocked, the aircraft weight would have driven it towards the retracted position. The speed of movement would have been limited by the maximum achievable rate of displacement of the fluid in the gear extend line,

bearing in mind the fluid leaking into and pressurising the landing gear lines as a result of flap operation.

Maintenance philosophy

It is not normal practice for organisations maintaining aircraft of types such as the PA23 to be equipped with, and make regular use of, hydraulic pressure gauges to establish precise details of pressure history's in flap and landing-gear lines during functional checks. If no problem is reported with the operation of these systems then there is no reason to assume other than that the systems are serviceable. Given the systems condition as described above, the landing gear collapse is likely to be the first occasion on which it becomes evident that a problem exists.

Design philosophy

The philosophy of the hydraulic system on the PA23 series does not accord with the standard of current Fault Mode Effects Analysis (FMEA) principles which have evolved over many years and are routinely applied by most aerospace design organisations. In this design, a single unit containing numerous valves immersed in the same hydraulic fluid performs two very separate functions. Chemical contaminants entering or forming in the fluid could readily cause deterioration of the sealing qualities of a number of those valves allowing internal fluid leaks This could lead to a variety of malfunctions occurring in flap and/or landing gear operation.

An analysis of the operation of both this system and those utilised on a number of other common light aircraft was carried out after the cause of this event was established. This analysis suggested that movement of an incorrectly extended landing-gear leg during salvage attempts, on any similarly disabled machine, is likely to result in corresponding retraction of another of that aircraft's legs. This may occur if any one of a variety of faults has resulted in an initial failure of the leg to extend fully or to remain fully extended once the aircraft is on the ground.

Subsequent action

The power pack was returned, by the owners, to an overhaul company in the USA for replacement under a service exchange scheme. The company are understood to be the only organisation now actively repairing and overhauling hydraulic power packs from PA 23 aircraft. They were requested to furnish a strip report on the condition of this unit. This report is still awaited. If on receipt it provides further useful information on the exact nature of the defect(s) the details will be published in a later issue of the AAIB Bulletin.