

EXTRACT COMPLIED BY D MARTINEZ
AS ALLOWED BY THE COPYRIGHT ACT

ARL-GD-37

AR-007-134

AD-A267 086



DEPARTMENT OF DEFENCE
DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION
AERONAUTICAL RESEARCH LABORATORY
MELBOURNE, VICTORIA

General Document 37

AIRCRAFT ACCIDENT INVESTIGATION AT ARL
THE FIRST 50 YEARS

by
J.L. KEPERT



Approved For Public Release.
© COMMONWEALTH OF AUSTRALIA 1993

MARCH 1993
93-16620

This work is copyright. Apart from any fair dealing for the purpose of study, research, criticism or review, as permitted under the Copyright Act, no part may be reproduced by any process without written permission. Copyright is the responsibility of the Director Publishing and Marketing, AGPS. Enquiries should be directed to the Manager, AGPS Press, Australian Government Publishing Service, GPO Box 84, CANBERRA ACT 2601

**DEPARTMENT OF DEFENCE
DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION
AERONAUTICAL RESEARCH LABORATORY**

General Document 37

**AIRCRAFT ACCIDENT INVESTIGATION AT ARL
THE FIRST 50 YEARS**

by

J.L. KEPERT

SUMMARY

Early Australian experience with the investigation of aircraft accidents is covered briefly as a prelude to the foundation of the Aeronautical Research Laboratory. With its foundation, a more scientific approach was possible. ARL was quickly involved with accident investigation, an activity which has been maintained throughout its fifty year history. This report examines ARL experiences during those fifty years with the idea of providing some useful guidelines for the next half-century.

DSTO
AUSTRALIA

© COMMONWEALTH OF AUSTRALIA 1993

POSTAL ADDRESS: **Director, Aeronautical Research Laboratory
506 Lorimer Street, Fishermens Bend 3207
Victoria Australia**

TABLE OF CONTENTS

Page No.

1. INTRODUCTION 1

2. EARLY AUSTRALIAN EXPERIENCES 1

3. THE A A I C 3

4. THE PUSS MOTH ACCIDENTS 5

5. THE DH.86 ACCIDENTS 7

6. THE DEMON AND ANSON ACCIDENTS 10

7. ARL AND THE ANSON WING 12

8. THE ROLLING PULL-OUT MANOEUVRE 14

9. SYMMETRIC OVERLOAD 24

10. ENGINE FAILURE 34

12. FATIGU E 54

13. HELICOPTERS 61

14. HUMAN FACTORS 75

15. CONCLUDING REMARKS 91

APPENDIX 1 Chronological List of ARL Publications on Aircraft
Accident Investigation 93

DISTRIBUTION

DOCUMENT CONTROL DATA

DTIC QUALITY INSPECTED 1

Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

1. INTRODUCTION

Flying and accidents seem to be indivisible as Icarus and Daedalus discovered when they attempted to escape the wrath of King Minos by flying from Crete to Sicily on waxed wings. According to the official accident investigation report, Icarus flew too close to the sun, the wax melted, and Icarus ended up in the sea. Some fishermen, discovering feathers floating on the surface and identifying these as ex - Icarus, called the area the Icarian Sea, by which name it is known to this day.

We now know that the altitude rating of waxed wings is far too low for the accident investigation report to be tenable. Further, a wreckage trajectory analysis based on the prevailing meteorological conditions and the terminal velocity of waxed feathers, indicates that the recovered feathers could not have come from the wings of Icarus. In consequence, the Icarian Sea has a position error of some 50 nautical miles.

The saga of Icarus and Daedalus established many traditions including the tradition of aircraft accident investigators to get things wrong. When ARL was founded in 1939, one of its tasks was to break with this tradition. This report examines ARL's experiences in this endeavour during its first fifty odd years in the hope that these experiences will serve as a useful guide for the future.

2. EARLY AUSTRALIAN EXPERIENCES

The first recorded attempt at flight in Australia also ended disastrously. On 15 December 1856, Pierre Maigre attempted to ascend from the Sydney Domain in his hot air balloon; a rope tangled and the attempt ended in a considerable bonfire which consumed balloon, support poles, spectator seats and M. Maigre's hat. In defiance of Icarian precedent, Sydney Harbour was not renamed.

The flying career of another early Australian balloonist, Henri L'Estrange, ended somewhat more dramatically on 15 March 1881 when his gas-filled balloon collided with the top of a house in Woolloomooloo. L'Estrange quickly made his way to the nearest public house just before the balloon exploded casting "a brief but vivid illumination over the entire suburb". A nearby drapers shop caught fire and L'Estrange, who had already achieved historical fame by making the first emergency parachute jump in Australia, decided to give up flying.

Early Australian attempts at powered flight fared little better. The first was when Colin Defries tried to coax a Wright Flyer into the air at Victoria Park Racecourse, Sydney on 4 December 1909. The attempt terminated abruptly when the aircraft struck logs hidden by the long grass. As aircraft became more numerous, and accidents more frequent, the techniques of accident investigation became more sophisticated. Meteorological phenomena were now recognised as an important factor and many accidents were ascribed to "a lack of lift in the air". There was no formal system for the investigation of aircraft accidents and these were left to the discretion of the pilot or the owner or to some other, generally inexperienced, body. The nett result was a wide variation in approach.

When John Duigan damaged his first aeroplane at Mia Mia, Vic. during September 1910, he correctly ascribed the accident to a loss of lateral control at low altitude. He promptly modified the design by replacing the rather ineffective interplane ailerons with conventional trailing edge ailerons and the trouble never recurred.

Duigan's second aircraft was basically an Avro Type D fitted with a 35 HP ENV engine. It was built at Ivanhoe, Vic. and then moved to Keilor in readiness for flight testing. On 17 February 1913, its first flight ended when a wind gust produced a rate of roll beyond the capacity of the lateral control system to correct. One wing tip touched the ground, the aircraft cartwheeled and was extensively damaged. Again Duigan correctly identified the fault, viz. the inadequacy of the wing warping system used, and wisely decided against rebuilding. The wreckage was sold to M. Paul Auriac who rebuilt it, subsequently making two or three short flights at Geelong. Its brief career ended in "a fall" into Wighton's Paddock during May 1914 according to the report of the local police.

This casual attitude to aircraft accident investigation was not confined to the Victoria Police. Basil Watson built a biplane resembling a Sopwith Pup at his home in Brighton, Vic. during 1916. Fitted with a 50 HP Gnome rotary engine, the aircraft proved quite successful and made numerous flights. On 28 March 1917, while performing loops over the army camp at Laverton, the port wing collapsed and the aircraft crashed into the sea killing Watson. The cause of the structural failure was never established, or even investigated, by the Australian Army. Immediately before its last flight, the covering of Egyptian cotton had been replaced by Assam silk, but whether this was a contributing factor will forever remain a mystery.

When a Sopwith Gnu of the Larkin-Sopwith Aviation Co. clipped a telephone wire with its tail and crashed while attempting to land at Mornington, Vic. on 2 January 1920, the sole passenger received fatal injuries. The coroner's report is worth quoting in full.

"An Inquisition for our Sovereign Lord King George V, taken at the morgue, Melbourne, in the State of Victoria, the 26th day of March A.D. 1920 in the tenth year *Uif* the reign of our said Lord King, by me, Alexander Phillips, gentleman, a Deputy Coroner of our Lord the King for the said State, upon the view of the body of Phillip Roffe Nunn then and there lying dead.

Having enquired upon the part of our Lord the King, when, where, how and by what means the said Phillip Roffe Nunn came by his death, I say that on the 4th day of January 1920 at Mornington Phillip Roffe Nunn died from injuries caused by the accidental overturning of an aeroplane in which he was riding on the 2nd January 1920".

As an insight into the cause of the accident, this leaves something to be desired.

The Mornington accident strongly influenced public perceptions that unregulated flying was no longer acceptable. In a flurry of activity, the Federal Government formed the Air Council and the Air Board with appointments gazetted on 12 November 1920. Supporting legislation was embodied in the Air Navigation Act 1920 and passed on 2 December. The Civil Aviation Branch of the Defence Department was formed with regulations coming into effect on 28 March 1921 and into law three months later. Finally, the Royal Australian Air Force was created out of several defence elements and attained formal existence on 31 March 1921.

One effect of these new arrangements was a marked improvement in the standard of aircraft accident investigations. This was not long delayed since the first accident to be investigated under the new arrangements, that to an Avro 504K flown by F/L Fryer-Smith at Laverton, Vic. occurred on 6 April 1921. The fifth accident to be investigated also involved an Avro 504K, one operated by the Shaw-Ross Engineering and Aviation Co.

On 22 May 1921, Lt H.G. Ross took off from Port Melbourne in the Avro on a joy-flight with two passengers, Cyril Harris and Sessica Dorman. When heading towards the bay, the aircraft suddenly fell into a spin and crashed into the yard of a cottage. There were no survivors. At the inquest, the CAB's Superintendent of Aerodromes, Capt E.C. Johnston, reported that he had examined the wreckage after the accident and found no fault with the machine or engine but that the heel of one of Miss Dorman's shoes had been almost wrenched off. "I am of the opinion that the accident was due to the unfortunate jamming of the heel of Miss Dorman's shoe, thereby rendering the rudder control useless and causing the machine to dive to the ground" he explained.

This simple explanation may well have been true. Certainly it represented a marked improvement over earlier practice. The trouble was that aeroplanes were becoming more complex, even if shoes weren't.

3. THE AAIC

During the 1920's, there was growing public disquiet at what was seen, probably correctly, as officialdom's rather elementary approach to the investigation of aircraft accidents. Events came to a head in 1927 when two accidents occurred before large crowds and, more importantly in the eyes of the daily papers, before the Duke and Duchess of York.

Their Royal Highnesses were visiting Australia to open the new Parliament House in Canberra with due Imperial pomp and ceremony. On 21 April 1927, during their official visit to Melbourne and just as the royal procession was turning from St Kilda Road into the grounds of Government House, two DH.9 aircraft of the RAAF flypast collided. The crowd of many thousands watched as A6-5 and A6-26 disintegrated and plummeted to earth in the vicinity of Sturt Street, South Melbourne. Fortunately, there were no casualties among the crowd but all four RAAF aircrew were killed making it the worst aircraft accident in Australia to that time.

Three weeks later, Their Royal Highnesses had the misfortune to witness the crash of SE-5a A2-24 during the opening ceremony in Canberra on 9 May 1927. The pilot F/O F.C. Ewen was killed. The following day, while returning from Canberra to Melbourne with photographs of the opening ceremony, SE-5a A2-11 suffered an engine failure and crashed in remote bushland near Whitfield, Vic. The pilot, Sgt Orm Denny, walked 25 miles to secure assistance.

This was too much for the newspapers. Bowing to the pressure, Sir William Glasgow, Minister for Defence, signed a Statutory Rule on 25 May 1927 under the Air Navigation Act of 1920 appointing an Air Accidents Investigation Committee. The committee was empowered to make an independent inquiry into aircraft accidents, to study probable causes and to suggest preventative measures.

Composition of the committee was:

- "* Professor Henry Payne, Melbourne University (Chairman)
- "* Mr Marcus Bell, Superintendent Defence Laboratories
- "* Colonel H.B.L. Gipps, Chief Inspector Munitions Inspection Branch
- "* Squadron Leader Eric Harrison, RAAF
- "* Captain E.J. Jones, Superintendent Flying Operations, CAB
- "* Flight Lieutenant William Palstra, RAAF (Secretary)

While some of these men had some previous experience in aircraft accident investigation, the relevance of others is doubtful and the NSW Section of the Australian Aero Club was quick to voice its disapproval.

The committee made a flying start by holding its first meeting at Victoria Barracks, Melbourne on 25 May. AAIC Report no. 1 covered the accident to DH.9C G-AUED at Tambo, Qld on 24 March 1927. This was the first fatal accident suffered by Qantas; the aircraft stalled on final approach and its three occupants were killed on impact. Then followed Reports 2-4 covering the DH.9 collision, A2-24 and A2- 11 respectively.

The committee plied its trade with considerable diligence to the extent that when the DH Moth A7-10 crashed at Point Cook, Vic. on 5 January 1930, the matter was addressed by AAIC Report no. 70. On 1 February 1931, membership was reduced from six to three as a government economy measure but the diligence, if not the intelligence, remained unimpaired. Thereafter, the committee seems to have run into an increasing amount of trouble, particularly when investigating accidents which could not be summarised simply as engine failure or pilot error. Accidents to the Jones Wonga VH-ULZ and the Puss Moth VH-UPM in 1932 produced a crisis.

The Wonga was a single engine, high wing monoplane designed by L.J.R. Jones and built during 0929-30. After successfully completing about 100 hours of flying, the aircraft crashed during a short test flight at Quaker's Hill, NSW on 16 June 1932. Eyewitnesses observed the aircraft to bank steeply before diving to the ground causing fatal injuries to both occupants. At the inquest held on 5 July 1932, the AAIC reported its conclusion that the accident had resulted from low flying and bad weather. Subsequently T.D.J. Leech, lecturer in civil engineering, University of Sydney, built a scale model of the Quaker's Hill area and tested it in the G.A. Taylor memorial wind tunnel. From these tests he concluded that the aircraft probably encountered severe turbulence when the loss of control occurred.

These findings, together with the unhappy experience of the Puss Moth described in the next section, promoted a crisis of confidence in the AAIC. In a report to the Federal Government, a voluntary committee of aeronautical engineers charged the AAIC with insufficient inquiry, faulty conclusions and unfair reflections on the ability of deceased pilots. It recommended that all of the personnel of the AAIC be replaced with experts drawn from appropriate professional and scientific fields. Faced with open rebellion, the government predictably closed ranks. On 21 April 1933, Sir George Pearce, Minister for Defence, stated that "the voluntary committee had adopted an attitude of superiority which neither the constitution or qualifications justify" and the AAIC lived to fight another day.

4. THE PUSS MOTH ACCIDENTS

The Puss Moth accidents are notable for four reasons; they were international in character, they resulted in the death of some famous Australian airmen, they promoted the application of scientific research to aircraft accident investigation, and they contributed, however subconsciously, to the establishment of ARL. They are worthy of closer examination.

The Puss Moth was a conventional high wing cabin monoplane with vee strut bracing. Designed by De Havillands as the DH. 80A, it proved highly successful; two hundred and sixty were built in the UK and a further twenty five were assembled in Canada. However, its early history was marred by a rash of accidents involving in-flight structural failure:

* 13.10.30	VH-UPC	Darling Ranges near Perth, WA
* 5. 5.31	ZS-ACC	Van Reenen, South Africa
* 13.11.31	ZS-ACD	Sir Lowry's Pass, South Africa
* 21. 5.32	G-CYUT	Ottawa, Canada
* 27. 7.32	G-ABDH	Churt, Surrey, UK
* 18. 9.32	VH-UPM	nr Byron Bay NSW
• 29.10.32	G-ABJU	Grenoble, France
* 7. 1.33	CF-APK	Tuscan Mountains, Italy
* 22. 6.33	HS-PAA	between Khonkaen and Udorn, Siam

Captain C.H.F. Nesbit, with two students, was killed in the crash of VH-UPC. Nesbit had previously flown with West Australian Airways before joining C.W. Snook to form Wings Ltd. This company formally registered VH-UPC just six days before it crashed. Captain L.H. Holden died in VH-UPM with Ralph Virtue. Following a distinguished war record (MC,AFC) with no. 2 Squadron Australian Flying Corps, Holden made a career in civil aviation. While flying his DH.61 *Canberra*, he located the missing *Southern Cross* i- the "Coffee Royal" affair. Among his crew on that occasion was Dr G.R. Hamilton, joint owner of the *Canberra* who also died in VH-UPM.

The crash of CF-APK ended the career of H.J. Hinkler. About Bert Hinkler, little need be said. The Puss Moth had faithfully carried him solo from New York to Venezuela, across the South Atlantic in 22 hours to Africa, then to the UK before finally letting him down while en-route to Australia. Whatever the problem with the aircraft, it showed no respect either to skill or experience.

Once the problem was recognised, the Aeronautical Research Committee set up an Accident Investigation Sub-committee with Sir R.T. Glazebrook as chairman. Among its distinguished company was H.E. Wimperis, Director of Scientific Research, Air Ministry, who later reported on the inauguration of aeronautical research in Australia at the invitation of the Federal Government. On his recommendation, the government established the Aeronautical Research Laboratory in Melbourne and a Chair of Aeronautics at Sydney University.

Investigations by local authorities had shown that, in all cases, the accident had resulted from the in-flight failure of one or both wings. Accordingly, the sub-committee began by investigating the static strength of the aeroplane. Tests by the manufacturer showed that

it easily met the load factor requirements of +5.5g and -2.75g specified for the normal category when the type certificate was issued in May 1930. Additional tests carried out by the RAE Farnborough supported this conclusion but indicated the desirability of fitting a stabilising bar to the forward leg of the vee strut; see Fig. 1. This mod was incorporated on 21 March 1932.

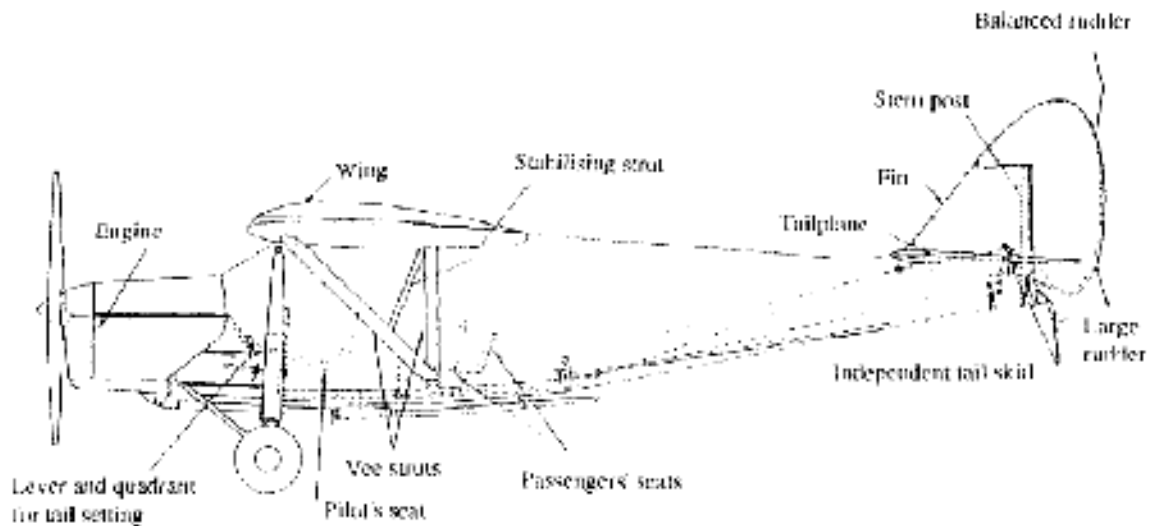


Fig. 1 D.H. Puss Moth showing location of stabilising strut

Some early occurrences of rudder flutter had been experienced in Canada. While these were not catastrophic, the fitting of rudder mass balances was directed by a mod dated 21 November 1932. However, the last two accidents were to aircraft incorporating this mod, and their wreckage showed no evidence of in-flight failures in the tail unit. Most significantly, the Australian report on VH-UPM was adamant that its tail surfaces, not mass balanced, were intact at ground impact and not a factor in the accident. This evidence, with the results from wind tunnel tests on a quarter scale flutter model of the Puss Moth rear fuselage and tail unit, led the sub-committee to reject rudder flutter as an adequate explanation of the accidents.

The wreckage from most of the accidents, including VH-UPM, was collected together in the UK and examined by the Inspector of Accidents. He observed that the wings all exhibited similar features. The spars were broken in several places, portions of each wing tip were missing, all the outer ribs were missing or badly shattered, the outer drag struts were broken and had pushed through either the front or rear spar. To the sub-committee, these features suggested that an appreciable fore and aft component of alternating strain, i.e. racking motion, had contributed to the wing failures. This, in turn, suggested the possibility of wing-aileron flutter particularly since the vee strut "contributes less torsional stiffness to the wing than would have been the case with the (then) more usual four point attachment to the fuselage."

Wind tunnel tests on a quarter scale model of the wing showed a critical flutter speed of 170 mph for the antisymmetric bending mode with zero backlash in the aileron control circuit. With backlash present, the critical speed was somewhat lower, and further

reduced when the fuselage attachments were allowed some freedom of movement. The mode exited contained a significant fore and aft component. This led the sub-committee to conclude that wing-aileron flutter was the most probable cause of the accidents. ARC Reports and Memoranda No. 1645, Report on Puss Moth Accidents, concluded "The subcommittee is strongly of the opinion that routine calculations or experiments on flexibility should be made for each design so as to cover the possibilities of failure due to the interaction of structural distortion and aerodynamic loadings".

This was a strong endorsement of the view, always held by the AAIC, that the accident to VH-UPC resulted from wing flutter. It had recommended the fitting of aileron mass balances three years before the sub-committee's report and the last seven accidents occurred to aircraft so modified. In its report on the accident to VH-UPM, the AAIC also drew attention to the fact that one aileron balance weight was missing from the wreckage and could not be located; in itself, highly suggestive of flutter. Following the subcommittee's report, improved aileron mass balances were fitted and the problem never recurred. The DH.85 Leopard Moth, successor to the Puss Moth, always featured prominent aileron mass balances; De Havillands didn't make the same mistake twice.

The Puss Moth accidents led to the first mathematical analysis of flutter reported in the now-famous ARC R & M 1699 Report on Puss Moth Accidents by R.A. Frazer, W.J. Duncan and A. R. Collar. This report is highly regarded as initiating scientific research into flutter. Flutter had of course occurred in earlier aircraft but had not been recognised as such. For example, it is highly probable that the wing failures which plagued the Albatros D.III, and more particularly the D.Va, arose from flutter. It is significant that the problem only arose when the parallel interplane struts of the earlier D.I and D.II were superseded by the vee struts of the later models.

In retrospect, it is clear that the AAIC performed commendably in the Puss Moth accidents. Its accident reports were detailed and accurate, it correctly diagnosed the problem at an early stage, and it recommended a possible solution. It could do no more since it lacked the necessary support facilities such as those made available to the Accident Investigation Sub-committee by RAE Farnborough. However, the AAIC performed less well in the DH.86 accidents.

End of Research
D Martinez
08/01/13