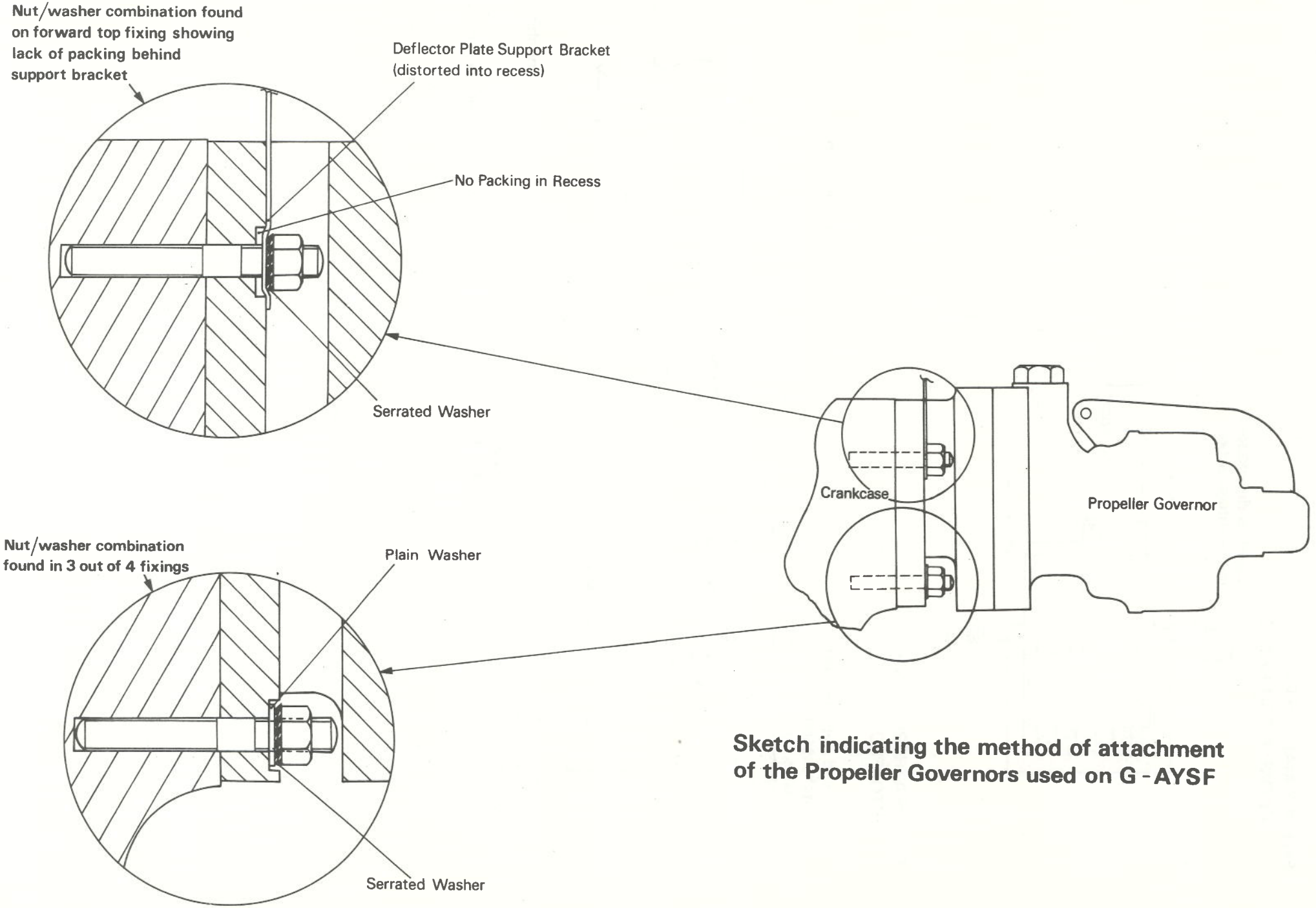



**Sketch indicating the method of attachment of the Propeller Governors used on G-AYSF**

Fig1 NORMAL OPERATION
IN FINE PITCH RANGE

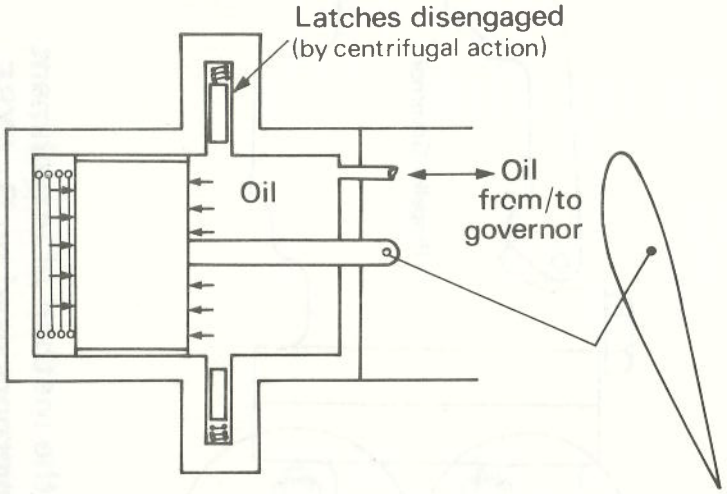



Fig2 FEATHERED AND
STOPPED

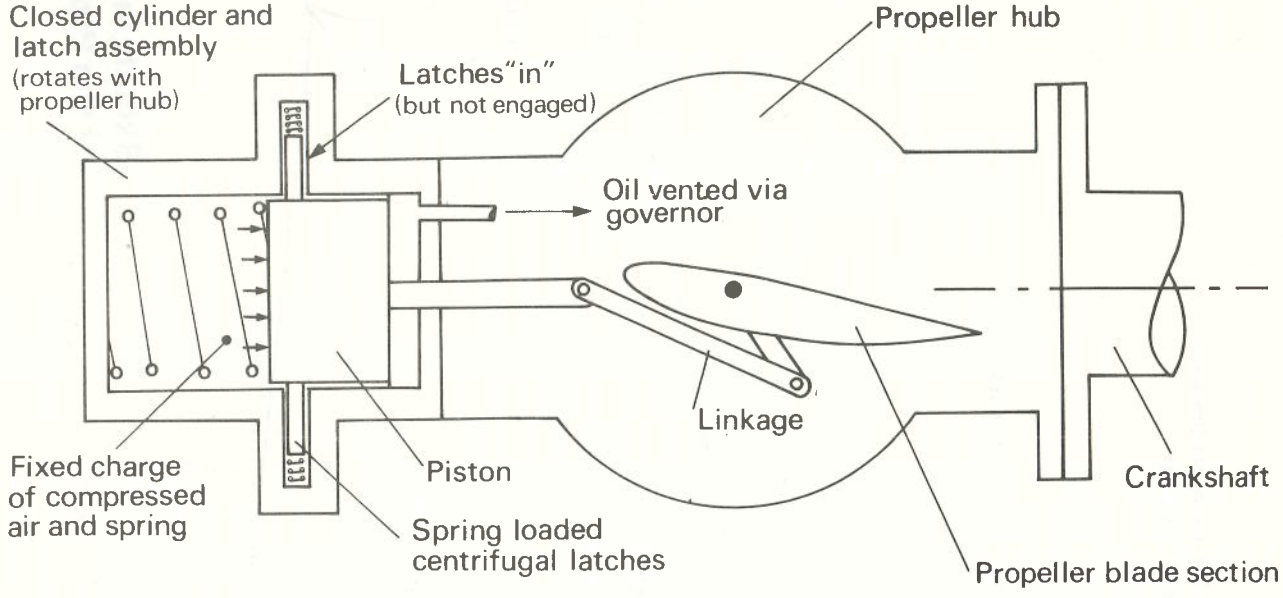
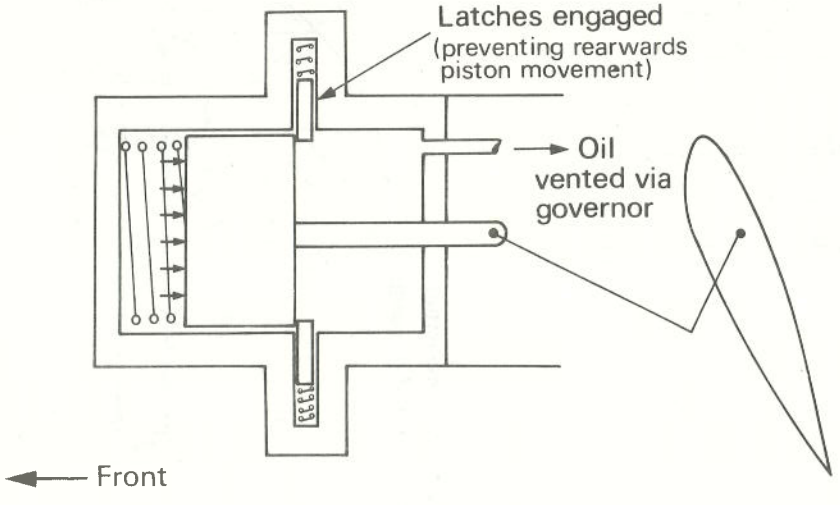
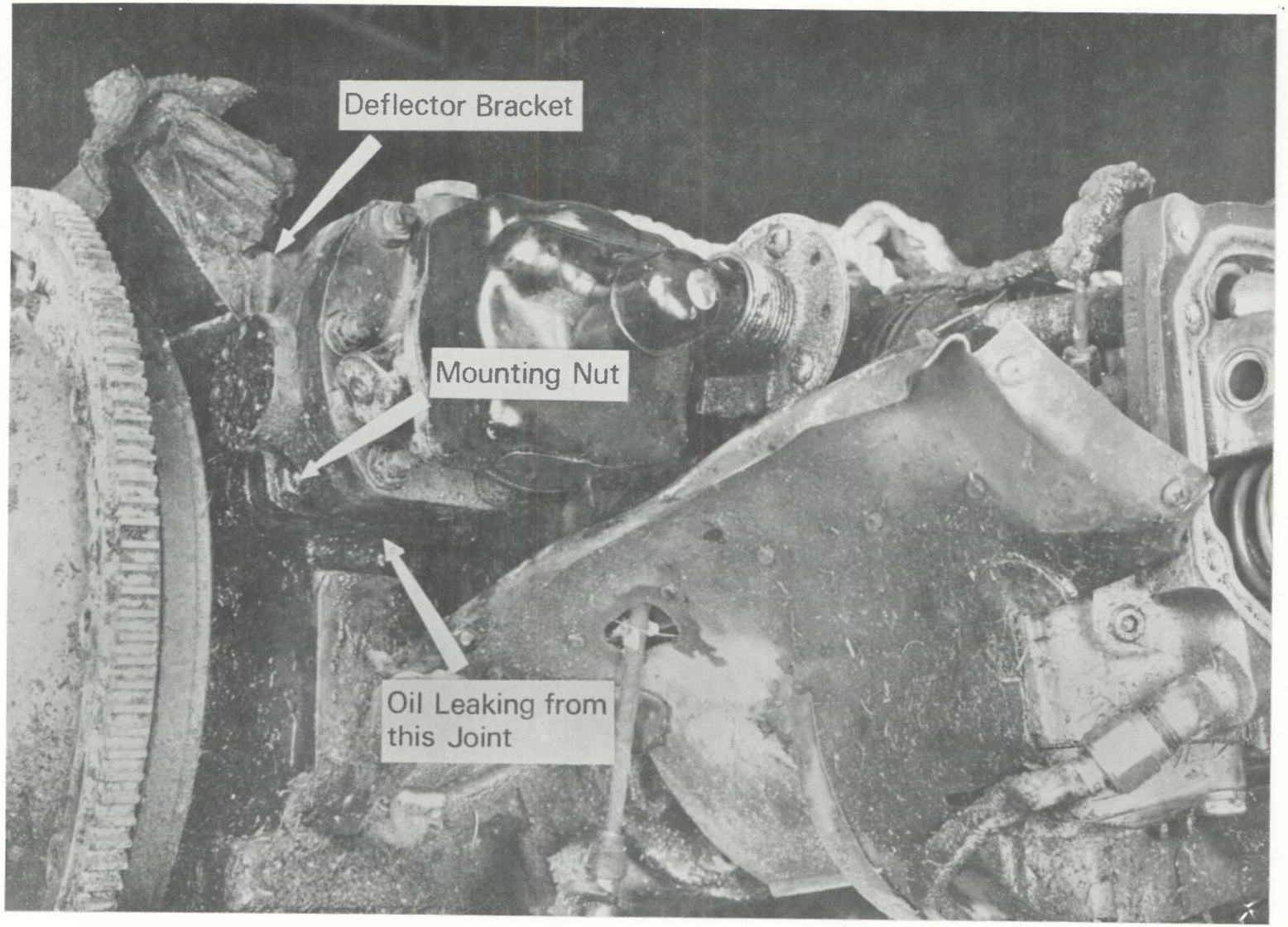



Fig 3 LATCHED CONDITION
(condition of left propeller
at impact)




**Schematic of propeller pitch change mechanism**




**G-AYSF: Port Propeller Governor Installation – showing oil seepage from attachment joint**

## Application for Review

# Part B

In conducting this investigation the provisions of Regulation 11(1) of the Civil Aviation (Investigation of Accidents) Regulations 1969, were complied with and representations made by Hartzell Propeller Inc were considered before the report was completed.

Following the submission of the report to the Secretary of State in May 1978, Hartzell Propeller Inc asked that the findings should be reviewed by a Review Board.

In accordance with the Regulations, the Lord President of the Court of Session in Scotland appointed a Review Board under Mr C E Jauncey QC, now the Hon Lord Jauncey, assisted by Captain Duncan McIntosh OBE AFC as pilot assessor and Mr John Barker as engine assessor.

# Part C

CIVIL AVIATION (INVESTIGATION OF ACCIDENTS) REGULATIONS 1969

# Review of the Report on the accident to Piper PA E 23 (Aztec) Series 250 G-AYSF at Moffat, Drumfriesshire, Scotland on 27 July 1976

## Report

before

Mr C E Jauncey, QC

now

The Hon Lord Jauncey

and

Captain Duncan McIntosh, OBE AFC *(Pilot Assessor)*

and

Mr John Barker *(Engineer Assessor)*

12 Moray Place
Edinburgh 3

29 March 1979

The Rt Hon John Smith MP
Secretary of State for Trade

Sir

I have the honour to submit my Report upon the Review of the aircraft accident report on the accident to Piper PA E 23 (Aztec) Series 250 G–AYSF on 27 July 1976.

In doing so I wish to place on record the invaluable and unfailing assistance which I have received throughout the Review and during the preparation of the Report from the Technical Assessors, Captain Duncan McIntosh OBE AFC and Mr John Barker.

I also enclose a Memorandum* which has been prepared by Captain McIntosh and which he has asked me to submit to you together with this Report.

I have the honour to be
Sir
Your obedient Servant

C E Jauncey

*Not reproduced

# Appearances

| | |
|---|---|
| Mr C N McEachran, Advocate and Mr Robert Black | (Instructed by the Crown Agent) appeared as Counsel on behalf of the Review Board. |
| Mr C K Davidson, QC | (Instructed by Messrs Shepherd & Wedderburn, WS) appeared for Hartzell Propeller Inc. |
| Mr J A Cameron, Advocate | (Instructed by Messrs W & J Burness, WS) appeared on behalf of Avco-Lycoming Inc. |
| Mr Harvey Crush | Of Messrs Norton, Rose, Botterell & Roche, Solicitors, London appeared on behalf of the Piper Aircraft Corporation. |
| Mr I R Hamilton, Advocate | (Instructed by Messrs Boyd Jameson & Young, WS) appeared on behalf of Air Navigation and Trading Company Limited. |
| Mr A C M Johnston, Advocate | (Instructed by Messrs Bonar, Mackenzie, WS) appeared on behalf of the Civil Aviation Authority. |
| Mr Scott Baker, QC (of the English Bar) | (Instructed by Messrs Hagart & Burn-Murdoch, WS) appeared on behalf of the Personal representatives of the deceased pilot. |
| Mr D J D Macfadyen, Advocate | (Instructed by the Solicitors Office, Department of Trade) appeared on behalf of the Accidents. Investigation Branch of the Department of Trade. |

Mr A D McKay of Messrs Patrick & James, WS appeared at the Preliminary Hearing on behalf of McDonald Aviation Limited but did not appear thereafter.

Mr J A D Innes of Messrs Dundas & Wilson, CS appeared on behalf of the representatives of the deceased passengers but asked leave to withdraw at an early stage in the proceedings.

# List of documents

Report dated 10 November 1977 on Engineering data prepared by C A Protheroe, Inspector of Accidents.

Report dated 8 November 1976 with addendum dated 1 April 1977 prepared by D W Squire, Chief Engineer, Engine Overhaul Department, CSE (Aircraft Services) Limited.

Report dated 22 December 1976 on tests carried out to determine rate of oil leak from propeller governor prepared by Hants & Sussex Aviation Limited.
(W Dietz and D Jackson)

Report dated 10 November 1976 on fuel test prepared by J Hughes for the Director of Materials Quality Assurance, MOD.

Report dated 12 January 1977 on oil test prepared by R F Tollervey for Director of Materials Quality Assurance, MOD.

Report dated 29 October 1976 on parts of propeller control unit prepared by A Q D Laboratories.
(Miss J W Harris and Mr V H Cripps)

Flight Test Report dated 1 October 1976 and addendum thereto prepared by D Cummings, Flight Test Engineer, Civil Aviation Authority, Airworthiness Division.

Copy letter dated 27 October 1976 from J R W Smith, Flight Test Engineer, Civil Aviation Authority, Airworthiness Division to Piper Aircraft Corporation.

Excerpt from Lycoming Operator's Manual.

Excerpt from Lycoming Parts Catalogue.

Excerpt from Tightening Torque Recommendations referred to in Lycoming Operator's Manual.

Report of LATCC FIR(N) Controller.

Flight Test Results by Mr Guinther for Hartzell.

Photographs.

Documents relating to Pilot's Aztec Training.

Engine Lubrication Diagram.

Letter from Pilot in Command of G–AYSF's previous flight.

Technical Log Sheet of G–AYSF's previous flight.

Aero-nautical Chart of Northern England.

Two Port Engine Log Books.

Port Propeller Log Book.

Piper Aircraft Corporation Flight Manual.

British Supplement to above Flight Manual.

McDonald Aviation Limited's Training and Operator's Manuals.

Certified Computer Print-out relative to reports concerning Hamilton Standard or Hartzell Propeller Governor Bolts or Nuts.

Port Engine Record.

Specification of C.S.U. Fixing.

Extract from Lycoming Operator's Manual.

Large Engine Drawing.

Copy Lycoming Service Letter.

Lycoming Engine Overhaul Manual.

Mr Light's Friction Horsepower Calculation.

C.A.A. Flight Test of G–AYSF.

C.A.A. Flight Test Schedule No. 3.

Drift Down Time Calculations for G–AYSF.

Three N.A.T.S. Radiotelephony Transcripts.

# Preliminary

## Accident

1 During a charter flight from Blackpool to Perth on 27 July 1976 a Piper PA E 23 (Aztec) Series 250 – G–AYSF struck a hill approximately 2,500 feet amsl. some 7 nautical miles north east of Moffat, Dumfriesshire at about 1756 hrs. The aircraft was destroyed by fire and the pilot and five passengers were killed. The flight in question was the return leg of a flight which had originated that morning at Perth in a Piper Aztec aircraft owned and operated by McDonald Aviation Limited although the pilot was employed by Tayside Aviation Limited. The aircraft in which the flight commenced became unserviceable at Blackpool and the pilot obtained a substitute aircraft from Air Navigation and Trading Company Limited. The circumstances in which authorisation was granted by McDonald Aviation Limited to the pilot to effect this change were not disclosed. The aircraft G–AYSF had returned to Blackpool from Leeds under the command of another pilot shortly before the final take-off for Perth.

## Investigation

2 The Chief Inspector of Accidents ordered Mr Westlake, a Principal Inspector of Accidents to carry out an investigation into the accident. Mr Westlake commenced the investigation with the assistance of Mr Cairns, an Operations Inspector and Mr C A Protheroe, an Engineering Inspector. Mr Westlake retired before the investigation was completed and Mr Cairns subsequently died. Mr P J Bardon thereafter became Principal Inspector and completed preparation of the report for submission to the Secretary of State for Trade. A copy of the proposed report was, pursuant to regulation 11, served upon Hartzell Propellers Inc, *inter alia.*

3 Hartzell Propeller Inc (hereinafter referred to as "Hartzell") gave notice that they wished the findings and conclusions in the report to be reviewed by a Review Board under Regulations 12 and 13.

## Proceedings of Review Board

4 On 9 October 1978 a Preliminary Meeting was held at which directions were given for the preparation and conduct of the Review.

5 At that meeting the following parties were granted leave to appear at the Review under Regulation 13(7):

Piper Aircraft Corporation

McDonald Aviation Limited

Air Navigation and Trading Company Limited

The Civil Aviation Authority

The representatives of the deceased passengers

The representatives of the deceased pilot

The Accident Investigation Branch of the Department of Trade.

6 On 15 November 1978 Captain Duncan McIntosh, OBE AFC (Pilot Assessor), Mr John Barker (Engineering Assessor) and I visited the Royal Aircraft Establishment at Farnborough in order to see the wreckage of the aircraft laid out in a hangar.

7 The Review Board sat in the Land Court, Edinburgh to hear evidence and submissions on nine days:

4, 5, 6, 7, 8, 11, 12, 13 and 14 December 1978.

8 Oral evidence was given by:

| | |
|---|---|
| Mr R F Tollervey | Higher Scientific Officer of the Materials Quality Assurance Directorate of the Ministry of Defence. |
| Mr D W Squire | Chief Engineer of C.S.E. Aircraft Services Ltd. |
| Mr J R W Smith | Flight Test Engineer, Civil Aviation Authority. |
| Mr C A Protheroe | Inspector of Accidents. |
| Mr P J Bardon | Principal Inspector of Accidents. |
| Mr W B Harlament | Chief Engineer, Hartzell Propeller Inc. |
| Mr J Bailey | Vice President of Aerospace Management Services International. |
| Mr W M Guinther | Pilot Instructor. |
| Mr V H Cripps | Senior Technical Officer, A.Q.D. Laboratories, Harefield. |
| Mr A E Light | Vice President Engineering, AVCO Lycoming Division, Lycoming Corporation. |
| Mr C F Wilson | Director of Engineering, Piper Aircraft Corporation. |
| Mr P E Reeve | Pilot Instructor. |
| Mr H Best Devereux | Consulting Aero-nautical Engineer. |

**Facts and Conclusions**

9 In the absence of any RTF transmission from the aircraft indicating distress or emergency, and in view of the extensive fire damage which occurred after impact the Inspectors were forced to build up, so far as they could, from the material available a probable reconstruction of the circumstances of the accident. Mr Protheroe, who was principally concerned with this reconstruction and who was present at the *locus* before the wreckage was removed concluded that distribution of the wreckage and the damage sustained by the seat frames and fuselage frames pointed towards a spin-type impact in which the aircraft had a high rate of descent with little forward speed. This conclusion was broadly accepted by all the parties present at the Hearing. Mr Protheroe also found the following facts which appeared to him to be of particular significance:

(1) A dent in the leading edge of one blade of the port propeller and chordwise marks in the vicinity of the dent.

(2) Damage to the underside of the port spinner in contrast to more general damage to the starboard spinner.

(3) Witness marks in the propeller cylinder assembly.

(4) The position of the port engine control cables in the cockpit which was similar to that in which they would have been if the pilot had taken action to shut down the port engine.

(5) The latches in the port propeller cylinder assembly which retain the propeller close to the fine pitch stop were all wholly or partially engaged.

(6) All four nuts securing the port propeller governor unit were loose and a 10 thousand feeler gauge could be inserted between the mounting flange and the crankcase.

(7) There was a quantity of oil distributed on the inside of the upper panel of the port engine cowling.

10 From these facts Mr Protheroe reached the following conclusions which were accepted by Mr Bardon:

(1) that the Governor Unit had become loose before impact with a consequential leak of oil therefrom;

(2) that for some reason, probably because he became aware of the oil leak, the pilot attempted to shut down the port engine;

(3) that he was unable to feather the propeller because windmilling r.p.m. had fallen unusually quickly below the minimum r.p.m. at which feathering was possible; and

(4) that this rapid decay of r.p.m. was due to increased friction in the engine consequent upon the loss of oil from the Governor Unit.

11 It was around these conclusions that the principal dispute took place.

**Governor Unit**

12 If the Governor Unit was loose before impact there can be no doubt that it could only have been as loose as it was found to be by Mr Protheroe for a very short time. The rate of oil loss through the gap at a pressure of 300 p.s.i. was calculated to be 2.7 imp. pints per minute which would have emptied the sump in a few minutes and this had not occurred. In reaching the conclusion that the Governor Unit had become loose before impact Mr Protheroe relied on the examination of the studs which secured it to the crankcase, which examination had been carried out by AQD Laboratories and on the amount of oil found on the inside of the cowling. There was, however, some doubt as to the extent of that examination. Mr Protheroe thought that the threads in the light alloy casting of the crankcase which received three of the four steel studs had been examined and found to be intact whereas Mr Cripps who carried out the tests considered that no such examination had been made since no mention thereof appeared in the Test Report. He further considered that distortion would be more likely to have occurred in the light alloy casting than in the steel studs and agreed that in the absence of information as to whether there was distortion in the casting the investigation could not be assumed to be complete. Mr Light with whose evidence as a whole I was much impressed also thought that failure or deformation of threads would first be found in the casting as happened in the case of the vacuum pump mounting studs and that in any event an examination after the studs had been withdrawn could destroy evidence of distortion because of the interference fit of the studs.

13 So far as the oil on the inside of the cowling is concerned there is no doubt that it could have come from a loose Governor Unit but it could also have come from other sources in the engine and the presence of oil in such a position and in such quantity is I am informed by my Assessors by no means unusual. It is reasonable to assume that the

prosecution of inquiries at the premises of Air Navigation and Trading Company Limited would have cast some further light on the likely source or sources of this oil. However Mr Protheroe did not interview any person who had been concerned with the maintenance of the aircraft during the weeks prior to its last flight nor did any such person give evidence. Furthermore no documentary evidence was obtainable from Air Navigation and Trading Company relating to the consumption of oil of either engine although I asked for production of any such records at the Preliminary Hearing and am informed by my Assessors that it would be very surprising if no such records had ever existed. Indeed the only information about the aircraft other than what was contained in the various logs produced was a short letter from the pilot who had flown it earlier on the day of the accident stating that during his flight there had been nothing unusual with the handling or the engine.

14 In the foregoing circumstances I consider that it would be unsafe to assume that the Governor Unit had become loose prior to the impact. However even if it had I am satisfied that no criticism can be levelled at the method of securing the nuts. Mr Protheroe agreed that the possibility of properly torque-tightened nuts coming loose was remote and Mr Light, in his very considerable experience, had never heard of one properly torque-tightened Governor Unit nut slacking off after a substantial period of trouble-free operation let alone four such nuts at the same time. Mr Light further considered that the system of nut and washers used to secure the Governor Unit was entirely satisfactory. In the absence of any suggestion that properly torque-tightened nuts on a similar Governor Unit had ever come loose before I consider that Recommendation 4.2 is neither justified nor necessary.

15 However the condition of the Governor Unit immediately prior to the accident is really peripheral to the circumstances with which this Report is concerned since a leak of oil therefrom can have done no more than precipitate the chain of events which resulted in the crash.

**Shutting Down the Engine**

16 In concluding that the pilot had shut down the engine at some time before impact Mr Protheroe relied on the position in which he found the port engine control cables in the cockpit as well as on the damage to the blade of the port propeller. This damage in Mr Protheroe's view suggested that the propeller was not under power at the time of impact in contrast to the damage on the starboard propeller which indicated that it was powered. It was sought to argue that no inference could be drawn from the position of the control cables because such cables were frequently displaced in an accident particularly where the engine in question was separated from its mounting. While I have no doubt that control cables can be displaced in a crash I consider that it was highly improbable that random displacement of the cables could have produced a result so consistent with some action having been taken by the pilot to reduce significantly the power on the port engine. Furthermore no reason other than a substantial reduction in power on the port engine was suggested as the cause of the spin. In these circumstances I consider that the pilot had probably moved the port engine controls to positions which would substantially reduce the power in the engine.

17 However I do not consider that it can be inferred on a balance of probabilities that the pilot had pulled the pitch control lever as far back as the feather position. On examination at the *locus* the difference in extension of the two throttle control cables was found to be 1.95 inches which, with a normal designed travel of 2 inches was indicative of full throttle on the starboard engine and closed throttle on the port. The difference in extension of the two propeller pitch control cables was 1.5 inches and the normal designed travel thereof was 2.25 inches. Thus if the two propeller pitch control cables had been in their relative positions at the time of impact the result would have been either that the starboard propeller pitch had been selected to coincide with the highest r.p.m., i.e. 2575 and the port control had not been pulled sufficiently far back to feather the propeller, which only occurs in the last one-half inch of travel, or the port

propeller had been feathered but the starboard lever had not been operated to produce full power. Both of these situations would have had a deteriorating effect on performance but from a consideration of the controls alone neither can be said to be more likely than the other.

**Position of Propeller on Impact**

18 Mr Protheroe concluded that the port propeller had not been feathered from the damage which he found thereon, and from the witness marks on the inside of the propeller cylinder assembly. The marks on the propeller blade and the damage to the spinner led him to believe that the propeller struck the ground in a position about 8 to 2 o'clock when viewed from the front and in fine pitch with the latches engaged. The witness marks were consistent with the piston in the cylinder assembly being very close to the fine pitch stop.

19 Mr Harlament on the other hand considered that the blade was driven into the fine pitch position by the impact having immediately prior thereto been at an angle of about $35^{o}$. He explained in considerable detail by reference to a model how, with the blade in approximately the same position in the quadrant as that assumed by Mr Protheroe, and at any angle from $15^{o}$ to the feather angle of $80^{o}$ the force applied by the downward movement of the aircraft when the tip hit the ground would bend the blade forcing it to rotate in an aft direction until the load applied to it forced the stop screw against the fine pitch stop by which time the latches would have engaged. The witness marks found on the fine pitch screw were consistent with the application of such force. Mr Harlament then expressed the view that by reason of certain marks on the pre-load Plates the blade had probably been at an angle of $35^{o}$ on impact.

20 I do not consider that the marks on the pre-load Plates upon which Mr Harlament relied, when these marks are compared with other pre-load Plates which were produced, support his conclusion as to the precise angle of pitch of the propeller when it hit the ground. I was however impressed by his evidence as to the likely effect of the impact on the blade and his reasons for concluding that the latches were not engaged at the time of impact. I therefore consider that it is more likely that the latches were not engaged when the propeller struck the ground.

**Behaviour of Port Engine on Pilot Reducing Power**

21 In his speech at the conclusion of the evidence Counsel for the Accident Investigation Board submitted that it was no longer appropriate to suggest that there was increased friction in the port engine as a result of the loss of oil. I consider that Counsel was absolutely correct in making this submission. The evidence of Mr Light as to the method of lubrication of the engine demonstrated conclusively that even if there had been a substantial loss of oil from the engine in flight it could not in view of the condition in which the engine was found have resulted in any increased friction due to overheating.

22 This submission by Counsel for the Accident Investigation Board must have a profound effect upon the conclusion that the latch engagement occurred at an air speed higher than normal. Although I have reached a conclusion that the latches were probably not engaged at the time of impact there can be no certainty in a matter such as this and it is proper that I should also consider the Findings which are subject to challenge upon the basis that the latches were engaged. Counsel submitted that notwithstanding the fact that any oil leak did not increase the engine running friction nevertheless the Board should have regard to possible variations in engine friction as a general proposition as a possible cause of latch engagement at a higher air speed than normal. I do not consider that this proposition has any foundation in fact.

23 Having regard to the distance travelled and the time which had elapsed since take-off it was generally agreed that at the time of the last radio transmission at 1752 hrs. the engines were likely to be turning over at about 2400 r.p.m. In normal course of events

30

after closing the throttle of an engine several seconds will elapse before the windmilling r.p.m., if indeed it is going to fall so far, falls below 1000 which is the limit below which, according to the Flight Manual, feathering is impossible, although in fact feathering is still possible at least down to 900 r.p.m. and possibly to 800 r.p.m. At the best single engine rate of climb which is 102 m.p.h. windmilling speed would stabilize at 1400 r.p.m. The time required to pull back the throttle lever to the closed position and to pull back the pitch control lever to the feather position is minimal. Thus unless r.p.m. had decayed abnormally fast after closing the throttle a situation would never arise in which, the normal procedure having been carried out, feathering would be impossible if the throttle were closed down from cruising speed. Such abnormal decay in r.p.m. from 2400 could not have occurred without some mechanical reason. No such reason, other than increased friction due to loss of oil was advanced and since that reason is now accepted as no longer valid I am driven to the conclusion that if the r.p.m. of the port engine did fall below that at which feathering was possible this was not due to any mechanical reason. It is significant that Mr Wilson, the Engineering Director of the Piper Aircraft Corporation knew of no case in their testing of the Aztec Aircraft where feathering had been impossible.

**Maintenance of Height with Windmilling Propeller**

24 In the proposed Report it was stated that "the effect of a windmilling propeller compared with a feathered propeller on a failed engine is therefore a decrement of 350 ft/min in Flight Manual Schedule data". This statement was based on tests carried out by Mr Cummings on a Piper Aztec "E" model G–AZWW on 3 September 1976. During the course of the hearing it was agreed that these results were not typical of an Aztec in as much as the performance of the live engine of the aircraft in question was sub-standard. The witnesses from the Accident Investigation Branch considered that a decrement of 220 ft/min was a more likely figure which would give a net rate of descent of about 50 to 75 ft/min. Hartzell relied on tests carried out by Mr Guinther on 22 November 1978 which showed that from 2000 to 3000 ft. with the left engine windmilling, the mixture control on, IAS 101.2 m.p.h. and the outside temperature at + 1°C a Piper Aztec with a gross weight at take-off of 4940 lbs climbed at the rate of 125 ft/min. Adjusting these figures to the temperature prevailing at the time of the accident would reduce the above rate by 35 to 40 ft/min. Furthermore these figures were carried out with the engine mixture control on which would mean that the engine was delivering idling power and therefore the propeller was producing less drag than if it was being driven wholly by the airstream. Mr Wilson had not carried out tests but he thought a figure of 220 ft/min decrement was reasonable although it might be somewhat on the high side. Evaluating this evidence as best I can and with the benefit of advice from Captain McIntosh the Pilot Assessor I consider that it is probable that if the port engine throttle had been closed, the mixture control off, the propeller windmilling and maximum power on the starboard engine the aircraft would not have been able to maintain height.

25 It was suggested that because of the results of an airworthiness test carried out on 13 May 1976 the performance of G–AYSF was substantially above average and that therefore even assuming that a 220 ft/min decrement was appropriate for a windmilling propeller nevertheless because of the increased rate of climb resulting from the extra performance deduction of that decrement would still leave a net rate of climb albeit small. The fact in the test upon which the foregoing argument was rested was the entry of 2450 r.p.m. as the continuous maximum power at which the single engine climb test was carried out, whereas maximum continuous power is developed at 2575 r.p.m. Since the rate of climb at the stated r.p.m. was 10 ft/min above the scheduled rate it followed that with maximum power on the live engine a rate of climb of the order of 80 ft/min in excess of the scheduled rate would have been achieved. The person who carried out the test did not give evidence and I am advised by Captain McIntosh that it is unlikely in the extreme that anyone would have conducted such a test with reduced rather than maximum power on the live engines. I do not therefore consider that any reliance can be placed on the figure of 2450 r.p.m. in evaluating the performance of G–AYSF.

**Findings in Relation to Challenged Conclusions**

26 *Finding (iii)* can no longer stand in view of my conclusions (a) that it would be unsafe to assume that the Governor Unit had become loose prior to the impact and (b) as to the position of the latches at the moment of impact.

27 *Finding (iv)* has already been emasculated by Counsel for the Accident Investigation Board's submission that it was no longer appropriate to suggest that there was increased engine running friction due to a partial loss of oil. However as I have also reached a conclusion that the latches were not engaged at the time of impact it follows that no part of this finding can stand. As I have already remarked even if the latches were engaged no mechanical reason has been advanced for their engagement at an airspeed higher than normal.

28 *Finding (v)* is a wholly accurate comment on the Feathering Procedure in the Flight Manual. However as I have reached a conclusion that feathering was not impossible and that in any event there was no reason for the r.p.m. to have fallen so rapidly as to engage the latches before feathering could take place and in view of Mr Wilson's evidence that he knew of no case during testing where feathering had been impossible I can no longer see any content for this finding.

29 *Finding (vi)* can properly stand for the reasons which I have given under the immediately preceding heading.

30 *Finding (vii)* was not challenged.

31 *Finding (viii)* ceases to have relevance to the accident in view of my conclusions as to the probable state of the Governor Unit nuts at the time of impact.

**Cause**

32 The cause as set out in the proposed Report is now no longer appropriate and should read "The accident was probably caused by a loss of control following an attempt by the pilot to shut the port engine down. The aircraft entered a spin from which there was insufficient height to recover".

**Other Matters in Report**

(1) *Factual Information*

33 1.12.2.1. (a) the words "and the crank case thread was also undamaged" at the end of the third paragraph fall to be deleted for the reasons which I have more fully developed under the heading of Governor Unit.

(b) the last sentence of the fourth paragraph should also be deleted for the above reasons.

34 1.12.2.3. In view of my conclusion as to the latches probably not being engaged at impact the second paragraph cannot stand in its present form and should be amended to read as follows:

> ("The examination of the pitch change mechanism and the damage thereto indicated that at the time of impact the latches were probably not engaged. The point of latch engagement for this type of propeller varies between individual propellers, but should lie in the range 19 to 22°. The fine pitch stop is normally set to approximately 14½° and the feather position is normally between 79 and 81°.")

35 1.16 Mr Bardon explained that the words "Flight Manual" at the bottom of page 9 should read "Owners Handbook".

36 The second paragraph on p10 accurately summarises the tests carried out by Mr Smith. However these tests were not carried out in order to reproduce the assumed situation which prevailed at the time of the accident but rather, as Mr Smith said, to obtain "factual information which substantiated the claims of the Flight Manual ". Mr Smith further stated that he did not think that the data derived from the tests had any relevance to the accident.

37 The third paragraph on p10 which accurately summarises the test carried out by Mr Cummings must now be read subject to the qualification that the starboard engine of the aircraft in question was sub-standard in performance and that a more likely figure of decrement when the live engine was developing normal power would be 220 ft/min.

(2) *Analysis*

38 In view of the conclusions which I have reached as to (a) the latches being disengaged at the time of impact, (b) the Governor Unit having been slackened by the impact, (c) there having been no mechanical reason for any unusual decay in r.p.m. on closing the throttle of the port engine the fourth and subsequent paragraphs of the analysis are substantially superseded and I do not consider that it would be profitable to attempt to correct and re-draft them in detail.

39 However in view of the submissions which were made to me I think it right to comment on the following sentence on p12 of the proposed Report:

> "Certainly the necessity to maintain 1000 r.p.m. in order to feather ought to be given greater prominence in the Flight Manual than is the case".

40 The relevant entry in the Flight Manual is as follows:

**"Feathering Procedure**

Open operative engine throttle to maintain altitude and airspeed.
MAINTAIN AT LEAST 102 MPH (BEST SINGLE ENGINE RATE OF CLIMB).

Inoperative engine procedure is as follows:

a. "CLOSE" throttle

b. Prop control "FEATHERED". PROPELLER CANNOT BE FEATHERED UNDER 1000 RPM.

c. Mixture control "IDLE CUT-OFF".

d. Ignition switches "OFF".

e. Electric fuel pump "OFF".

f. Main fuel valve "OFF" inoperative engine."

41 Feathering is not a procedure which is only carried out by a pilot when an engine becomes inoperative but a procedure which he requires to carry out as a pre-flight test before every take-off. Thus a pilot must be aware of the Flight Manual procedure before he ever flies the aircraft and in these circumstances the fact that the words "PROPELLER CANNOT BE FEATHERED UNDER 1000 RPM" succeed rather than

precede the words "Prop Control FEATHERED" ceases to have any significance since the pilot is not operating the controls and reading the Flight Manual at the same time. Indeed Captain McIntosh advises me that as matter of practice a pilot should know all the information contained in the first 8 pages of the Flight Manual by heart. In these circumstances I see no need for any alteration of the way in which the feathering procedure is set out in the Flight Manual.

**Other Matters**

42 The conclusions which I have arrived at in relation to the Challenged Conclusions and the Analysis are unsatisfactory insofar as they substitute no positive conclusions for those of the Inspectors which I have rejected. No party to the Review Proceedings sought to put forward any positive alternative reason why this accident happened and no evidence emerged from which I could safely draw any conclusion as to a positive alternative. Indeed it is implicit in the proposed Report and the detailed reasoning therein contained that any conclusion as to the cause of this accident could only be reached by making assumptions from such material as was available. However there are certain matters upon which it is appropriate that I should comment.

**Reason for Pilot Reducing Power on Port Engine**

43 If there was no oil leak from the Governor Unit why did he do it? This must necessarily be speculative but it is not without significance that the port engine log book contained a great number of entries covering general maintenance work which suggests that this engine might have been a rougher unit than the starboard. When the fuel injection nozzles of the port engine were flow tested after the accident by C.S.E. (Aircraft Services) Ltd one was found to be blocked and the other five had erratic flow. If the nozzles were in those conditions before the accident they would, I am advised by my Assessors, undoubtedly have produced rough running. The pilot had never flown this aircraft before the flight and it is therefore possible that he had been concerned by the rough running of the port engine and reduced power.

**Height of Aircraft Prior to Accident**

44 At 1747 hrs. the pilot informed Sc. A.T.C.C. that he was descending to 3000 ft. to remain V.M.C. and at 1752 hrs. he informed Sc. A.T.C.C. of his intention to climb back to F.L. 35 to remain "V.M.C. on top". At this time his route involved flying over high ground up to 2756 feet amsl.

45 The Operations Manual of McDonald Aviation Limited who were the operators of the aircraft, provides *inter alia*:

"35-00 **MINIMUM SECTOR ALTITUDE**

The minimum flight altitude as defined below will be recorded on all Company Flight Plans.

(a) *Flight in controlled airspace* where the track is well defined by two separate aids not greater than 100 NMS apart, the minimum sector altitude will be 1500 ft. (on QNH) above the highest terrain or obstacle within 10 NMS of the intended track.

(b) *All other Flights*

1500 ft. (on appropriate QNH) above the highest ground or obstacle within 20 NMS of the intended track.

(c) For flights within 20 NMS of terrain having a maximum elevation exceeding 2000 ft.. the above clearance of 1500 ft. must be increased in

accordance with the table below, this applies to all flights including those in controlled airspace. The Captain must be conversant with the effect of Mountain Waves as outlined in Information Circular 7/68.

35-01

| ELEVATION OF TERRAIN | WINDSPEED | | | |
|---|---|---|---|---|
| | 0–30 | 31–50 | 51–70 | OVER 70 |
| 2 – 7000' | 500' | 1000' | 1500' | 2000' |
| Above 7000' | 1000' | 1500' | 2000' | 2500' |

"

46 It is clear that immediately before the accident the pilot was not carrying out the above instructions.

47 If immediately before the accident the pilot was flying in or near the tops of cloud as Mr Bardon assumed it would appear that he was not observing rule 23(a) (i) of the rule of the air and Air Traffic Control Regulations 1974 (SI No. 1401) which provides:

"23. The Visual Flight Rules shall be as follows:

(a) Outside controlled airspace

(i) an aircraft flying outside controlled airspace above 3,000 feet above mean sea level shall remain at least one nautical mile horizontally and 1,000 feet vertically away from cloud and in a flight visibility of at least five nautical miles;"

48 While the height at which the pilot was flying immediately before the accident was in no sense a cause of the events giving rise to the accident, there is no doubt that had he been flying higher above the ground there would have been more time available for him to recover from the spin.

**Pilot Inexperience and Error**

49 The Pilot who was 22 years of age at the time of the accident had obtained his commercial pilot's licence on 3 May 1976. He had commenced training with Tayside Aviation Limited on an Aztec on 27 April 1976 and completed it on 30 April 1976. He had thus less than 3 months experience in flying Aztec's between the conclusion of his training and the date of the accident.

50 It was suggested to Mr Bardon in cross-examination that the pilot had stalled the aircraft but he rejected this suggestion on the ground that this "would require a piece of really gross mishandling on his part". Mr Bardon having reached a conclusion that the latches had engaged prior to impact also rejected the suggestion that any action of the pilot had caused the latches to reach that position before the pitch control lever had been operating. I do not think that I am being unfair to Mr Bardon in stating that he never really considered that there might have been a human rather than a mechanical cause for this accident. In the light of the pilot's very limited experience I am not sure that this was not rather too naive an approach.

51 Even if the port propeller could not have been feathered this should not necessarily have produced fatal consequences. I am advised by Captain McIntosh that in the conditions prevailing at the time an experienced pilot would have been able to arrest any spin which developed by reducing power on the starboard engine and might well have been able to land the aircraft on flat ground without such disastrous consequences as here occurred.

52 There was not before me such evidence as would justify the making of any finding that the accident resulted from an error on the part of the pilot. However there being no mechanical explanation for the aircraft developing a spin, other than possible rough running of the port engine which may have induced the pilot to reduce power I do not consider that a human cause be it attributable to error or merely to lack of practical experience in circumstances other than normal can be altogether ruled out.

C E Jauncey, (*now The Hon Lord Jauncey*)

We agree with the contents of this Report.

Captain Duncan McIntosh, OBE, AFC *(Pilot Assessor)*

John Barker *(Engineer Assessor)*

Produced in England by Her Majesty's Stationery Office, Reprographic Centre, Basildon



Bas 55886/R143 595791 TP