THIS IS A REFORMATTED VERSION OF
THE ORIGINAL APPENDICES TO THE
REPORT ON
ACCIDENT TO
VISCOUNT 803 AIRCRAFT EI-AOM
NEAR TUSKAR ROCK, CO. WEXFORD
ON 24th MARCH, 1968
APPENDICES TO THE REPORT ON AN INVESTIGATION
MADE UNDER REGULATION 7 OF THE
AIR NAVIGATION (INVESTIGATION OF ACCIDENTS)
REGULATIONS, 1957 (S.I. No. 19 of 1957)

The Report into this accident was originally published in 1970. However the Appendices to the Report were not published, but were available for inspection at the offices of the then Department of Transport and Power. Due to continued public interest in this accident, the Appendices to the Report are now republished on the Air Accident Investigation Unit web-site.

In order to publish the Appendices on a web-site, it has been necessary to electronically re-format the original documents. The quality of the original text precluded scanning of the original document. The Appendices were therefore re-typed in full. No editorial changes, or corrections to the original text, have been made during this re-typing. The original drawing and graphs were scanned, and only enhanced where the scan of the original document was unsatifactory and illegible.

Each page of the orignal Appendices have been reproduced as a separate web page. This format was selected in order to keep as close to the format of the original Appendices.

Some of the drawings and the map at the end of Appendix 6 were originally produced in approximately A2 size. To facilitate the reader, this version of the Appendices contains these drawings and the map in two formats.

1. In the first format is the drawing or map reduced to a single A4 size, so that the complete page can be viewed. This, however, results in some loss of detail.

2. The second format consists of the drawing or map split into three pages, each to original size, which can be used to produce a full size mosaic of the origina

Appendices (**Main Menu**)

1. Report on search and salvage – "Operation Tuskar".

2. Transcripts of tape recordings of R/T exchanges between EI-AOM and Air Traffic Services (Air Traffic Control Services).

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4. Investigation of recovered wreckage –
   - airframe;
   - engines and propellers.

- Investigation of auto-pilot.

- Summary of witnesses' statements – map of witnesses' locations.

- Photographs.

Appendix 1

"OPERATION TUSKAR"

SEQUENCE OF EVENTS

24th March 1968	Viscount EI-AOM. Missing on flight Cork to London about noon. Last reported position "By Bannow". Search and Rescue operations commenced about 1230 under coordination of R.N. Brawdy. Search directed more towards Welsh coast. Involved on Irish Coast side – Aer Lingus, Air Corps, Private Planes. RNLI Lifeboats, Local Fishing Vessels
25th March	"Macha" at Killybegs, alerted 250020. "Macha" sailed from Killybegs 0232. First bodies recovered N.E. of Tuskar by H.M.S. "HARDY", H.M.S. "PENELOPE" and RNLI Lifeboats. Engaged in search – above R.N. vessels, RAF Shackleton, Air Corps Dove and Helicopters, Arklow, Rosslare, and Kilmore Quay Lifeboats, local fishing vessels from Rosslare, Arklow, Kilmore Quay, Dunmore East, Private Plane.
26th March	1. L.E. "Macha" relieved H.M.S. "HARDY" as Search Controller at 1335. 2. HMS "HARDY" and HMS "PENELOPE" withdrew approx. 14.00 Shackleton withdrew at dusk. 3. Broadcast "All vessels willing to help to report to "Macha" for coordination". 4. Engaged: RNLI Lifeboats, Air Corps Dove and Helicopters, Local fishermen. 5. C.O.N.S. detailed as Search and Recovery Coordinator. 6. Datum buoy established by "HARDY" - 52°.14N. 06°.7.5W 7. "Cliona" ordered recall crew from leave and sail at once for Rosslare. Indicated would proceed 2000.
27th March	L.E. "Cliona" joined L.E. "Macha" on search. Also engaged RNLI Lifeboats, Fishing vessels, Air Corps Dove and Helicopters. Contact with R.N. Plymouth on provision of ships and personnel to carry out search. Sanction to engage RN facilities on a repayment basis. Lieut. Deasy appointed to Rosslare and detailed report there as C.O.N.S. representative with Communications Party and equipment 1400 Thursday 28th March.
28th March	1. Coordination Centre set up at Rosslare at 1400. 2. R.N. Party arrived by road from Dublin 1830. 3. Full scale coordination Conference 1900 – R.N., Irish Lights, Aer Lingus, Gardai, Harbour Master, Customs and Excise, Transport and Power, Naval Service.

- Search still continuing with "Macha", "Cliona", Air Corps, RNLI Lifeboats, Local fishermen.

29th March

1. Search for bodies continuing. "Macha", "Cliona", "Atlanta", Air Corps and Local fishermen.
2. Body search called off 1700. As no possibility of survivors, NOT justified in continuing with Volunteers. Search now a State responsibility.
3. Telex arrangements made with Met Office for use by RN in Communicating Plymouth.
4. HMS "SHOULTON" (Minehunter) and HMS "CLARBESTON" (Minesweeper – Diving Accom. Ship) arrived 1535.

30th March

1. Search for wreck commenced by HMS "SHOULTON" with HMS "CLARBESTON" in attendance to dive and investigative contacts.
2. Lifeboats and local fishermen returned local ports.
3. Search for bodies and flotsam continuing with "Macha", "Cliona", Air Corps, "Atlanta" and private plane.
4. Full scale conference on procedure to beach wreck. Details of Salvage Operation outlined by Command Salvage Officer, Plymouth, and full discussion on what is required in certain contingencies, sealing off beach, boat patrols, banning of planes, crowd control, traffic control, Information Centre, G.I.B. etc.
5. Agreed daylight working only and any landings on pier to be between 1230 and 1630 only.
6. Arrangements made to hire trawlers as necessary.
7. Trawling prohibited within 6 miles of Tuskar. Request broadcast by R.E. and passed to Gardai, B.I.M. and local harbour authorities. "Macha" informed to chase.
8. Command Salvage vessel "Uplifter" put on notice at Milford haven.

31st March

1. Wreck search continues.
2. Body search and flotsam search continued with "Cliona", Air Corps and "Atlanta". "Macha" temporarily withdrawn.

2nd April

1. Strong N'ly Winds.

2. No wreck search.

3. "Macha" and Air Corps Dove continuing body and wreckage search.

4. Air Corps personnel briefed at Baldonnel by CONS on conduct of search and general intentions.

3rd April	`Surface search "Macha" and Air Corps Dove. Bottom Search, H.M.S. "Shoulton"
4th April	Bottom Search, H.M.S. "Shoulton" and "Clarbeston" "Macha" and Air Corps Dove on Surface Search.
5th April	Bottom search H.M.S. "Shoulton" and "Clarbeston" "Macha" and "Cu na Mara" on Tidal Experiments. From 5th April onward, depending on weather pattern, HMS "SHOULTON" and HMS "CLARBESTON" on bottom search either "Macha" or "Cliona" and "Cu na Mara" on tidal experiments or surface search. Air Corps provided D and/or Helicopter on request for particular searches.
16th April	M.T. "Glendalough" hired to carry out trawling operations in company with "Cu na Mara". Trawling commenced.
20th April	HMS "SHOULTON" and HMS "CLARBESTON" returned Britain maintenance. Trawling and Surface search continues with "Glendalough", "Cu na Mara", "Cliona" and Air Corps.
3rd May	"Cu na Mara" withdrew to Dublin for winch repairs.
6th May	H.M.S. "SHOULTON" and HMS "CLARBESTON" returned to area and recommenced bottom search.
16th May	"Cu na Mara" resumes trawling.
20th May	H.M.S. "CLARBESTON" withdrew to Plymouth. C.S.V. "UPLIFTER" arrived with divers to replace "CLARBESTON".
21st May	H.M.S. "Reclaim" arrived in area to assist H.M.S. "SHOULTON" in identifying contacts by diving on them.

24th May H.M.S. "RECLAIM" withdrawn temporarily.

29th May H.M.S. "RECLAIM" returned area.
CSV "UPLIFTER" returned to Milford Haven.

5th June 1200 "Glendalough" hauled in position 1.72' from Tuskar with Tuskar bearing 280° in 39 fm and brought following wreckage to surface:-

a. Main fuselage 650 Station to part of Dorsal fin including Upper Main door frame, Port Aft.
b. Galley Power Control Panel
c. Window frame believed to be the one immediately forward of main door.
d. Waste pipe from forward toilet.

1400 "Cu na Mara" hauled same position and got following:-

a. 3ft. length hat rack padded bar.
b. Unidentified piece – probably wing piece.

1800 "Glendalough" hauled same position and brought up:-

a. Window rubber with handle from No.5 window, portside, from forward.
b. Primary silencer from pressurisation and air conditioning system position.
c. Small piece perspex window 2" x 2".

6th June 1400 "Glendalough" hauled same position and brought up:-

a. Part of forward main cabin door.
b. Main spar outer wing 7 ft. off.
c. Rolls Royce Dart Engine air intake.
d. Passenger Air conditioning panel.
e. Galley Hot Jug.

6th June 1430 "Cu na Mara" hauled same position and brought up:-

a. Engine nacelle cowling.
b. Small piece of fuselage structure passenger window area.

H.M.S. "Reclaim" investigated position by diving.
Confirmed mass of wreckage – "like a scrap yard".

2330 Due to tides operations abandoned until Tuesday 11th June "Cu na Mara" returned Dublin to report back 1400 Tuesday 11th. Glendalough returned Kilmore Quay to report back 1400 Tuesday 11th. "Shoulton" and "Reclaim" sailed for Plymouth.
"Cliona" returned Base.

7th June (1200)	Co-ordination Centre closed down until 1400 Tuesday 11th June.
11th June	"Cu na Mara", "Glendalough" and "Cliona" returned area and resumed bottom search clear of wreckage area.
12th June	H.M.S. "NURTON" (Cdr. Seymour) and H.M.S. "Bronnington" (Lt. Cdr. Perry) resumed bottom search East of Tuskar.
13th June	H.M.S "SHOULTON", HMS "Reclaim" and CSV "Uplifter" rejoined - preparing moorings and positioning of "Reclaim".
15th June	H.M.S. "Bronnington" withdrew.
16th June	"Reclaim" on moorings attended by "Shoulton" and "Uplifter", "Nurton" investigating. "Cliona" keeping small craft clear.

Report of survey of bottom.

"Wreckage 75' long, 15' wide and up to 5' high. Like a junk yard". Survey 60%

Picked up:

1 small piece seat rail
4ft. hat rack
3ft. push pull control
Fishing reel
Telaflex control
Front and rear seat leg
Nose wheels
1 Prop blade
1 Washbasin
Large piece of fuselage skin – green 10' x 6, 10' x 5'

Piping which appears to be pressurisation ducting.

Tubing – engine bearer.

17th June H.M.S. "Nurton" withdrew.

Report

1. Starboard outer wing completely shattered

2. Port wing detached from root
3. Rear fuselage section detached at trailing edge of wing
4. Passenger floors broken into small sections
5. Light luggage rack shattered into small pieces
6. All passenger seats failed in forward direction
7. One propeller blade visible
8. No engine seen
9. Big piece which could be nose section forward of leading section of wing, with debris scattered over it.

19th June — Extract from urgent verbal report from "Reclaim"

a. Think all in one piece
b. Nose wheel bracing is only lift
c. Cockpit and fuselage – 30 to 40 feet
d. Wings detached
e. Stropping

21st June — Centre spar and wing wreckage pulled on heaving.
Wreckage landed by "Reclaim" and "Uplifter" 1400.

22nd June — "Stood down" operations – tides too strong – until 15th July. Terminated trawling activities until further notice. H.M.S. "Shoulton" and CSV "Uplifter" left area.

Irish Lights laid wreck buoy seaward of wreck position "Cliona" withdrew to Base.

23rd June — H.M.S. "Reclaim" withdrew.

14th July — H.M.S. "Reclaim", H.M.S. "Shoulton" and CSV "Uplifter" arrived back in area.

15th July — Salvage operations resumed by R.N. Ships.
"Cliona" in attendance.

18th July — H.M.S. "Shoulton" withdrawn and returned to Plymouth.

19th July — H.M.S. "Iveston" joined "Reclaim" at salvage area.

20th July — H.M.S. "Iveston" withdrew.

22nd July — Attempt to lift stropped "centre section" failed.

9 strops – pulled - found to have been fast to all parts of aircraft.

23rd July — In attempting to lift "large piece" with one strop held together by piping and electric wiring, came to surface but crashed back on being hauled clear of water.

1530 "Uplifter" unloaded wreckage recovered during previous 10 days – 2.5 tons approx. mostly engines.

24th July — "Stood down" operations due to tides until Aug 13th 1968.
"Uplifter" sailed 0930, "Cliona" 1000 and "Reclaim" 1030.

13th August — Co-ordination Centre reopened 1400
"Cliona" returned Rosslare.
HMS "Reclaim" and CSV "Uplifter" returned salvage area.

14th August — Salvage operations resumed – "Reclaim" and "Uplifter" with "Cliona" in attendance.

16th August — "Cliona" withdrawn to deal with "Mine" off Kish.
"Macha" replaced "Cliona" at Rosslare.

<u>1630 Siterep from "Reclaim"</u>

1. "Tidal conditions reasonable.
2. T.V. operated for only 20 mins due to leaks. Engineer effecting repairs and will try camera again this afternoon.
3. "Uplifter" unable relay 4 ton clump last night on account westerly winds. Clump relayed at 0800 this morning. Am trying to reposition new clump alongside wreckage using small T.V. while tide is running and divers search at slack water.
4. Given reasonable service from T.V. am confident wreckage will be relocated shortly.
5. Will continue until wreckage located sending further siterep tonight."

<u>2300 Sirerep from "Reclaim"</u> "nothing to add to my 161630"

18th August — From "Reclaim" at 180843.

Have picked up following pieces:-

1. No. 4 Engine Compressor complete with impellor.
2. No. 4 Engine Nacelle structure complete, also exhaust cone and jet pipe.
3. 1 Main fuselage frame.

4. Static inverter
5. Small portion of main lower fuselage frame including starboard inner wing trailing edge member pick up point. Have them aboard. Still working".

19th August — From "Reclaim" at 191400.

1. T.V. search indicates that major pieces of wreckage are silting over making it increasingly difficult to find by camera.
2. Have recovered by diver (A) 4 square feet of inner wing skin (B) one electrical generator.
3. Camera damaged, extent not known. Intend continuing search with small camera while tide is running and by diver while tide is slack.
4. Strong winds and manoeuvreability of the ship for T.V. lens necessitate relaying bow moorings".

At 191445

1. Southerly wind force 7, and 12 to 14 foot swell preclude further operations until weather moderates.
2. Television camera partially repaired available for limited use."

20th August — Following discussions with Transport and Power and C in C Plymouth it was decided to terminate salvage operation on 21st August. Following sent to "Reclaim" (DTG 200945) from CONS.

"Have discussed following with C in C Plymouth and he concurs.

1. Salvage operation to terminate Wednesday 21st August.
2. Wreckage to be landed Wednesday afternoon as soon after ferry sails as convenient.
3. In view of proposal to trawl area clumps and anchor which broke adrift to be recovered if possible.
4. All moorings to be recovered by "Uplifter" before departure. At 201230 on 20 Aug. following made from CONS to "Reclaim" "Action" on para 4 of my 200950 be deferred 24 hrs. at request of C in C Plymouth".

21st August — "Reclaim" landed small amount of wreckage. "Reclaim" and "Uplifter" sailed for Plymouth and Milford Haven respectively.

"Macha" returned Naval Base.

29th August — "Uplifter" lifted all moorings and anchors, leaving area clear.

9th Sept.	Work resumed on recovery of wreckage by trawling using trawlers "Cu na Mara" (Skipper Ronan Mallen) and "Glendalough" (Skipper W. Bates) assisted by L.E. "Macha" and co-ordinated by Lieut. Deasy and small communications party at Rosslare. Due to weather and tides, work was only possible on 9th, 10th, 11th, 12th, 13th, 17th and 18th September, and, due to weather, operation was abandoned on 20th September. During this period the following wreckage was recovered:	

10th Sept -	"Glendalough"	Small pieces of wreckage from centre section.
	"Cu na Mara"	Two small pieces of wreckage.
11th Sept -	"Glendalough"	Trim tab from tail. Small pieces of centre fuselage. Booster pumps.
12th Sept -	"Glendalough"	Small pieces of fuselage wreckage.
	"Cu na Mara"	Large piece of outer wing
		Several pieces of fuselage fragments
13th Sept -	"Glendalough"	Large piece of skin from wing Rudder Torque Tube Considerable quantity of small pieces of various wreckage.
	"Cu na Mara"	Rear door
		Compressor
		Considerable quantity of small pieces
17th Sept -	"Glendalough"	6' piece of main flap
		Small pieces of fuselage and wing
		Parts of radio (Auto. D/F)
		Frame from Cockpit.
	"Cu na Mara"	Two small pieces of fuselage
18th Sept -	"Glendalough"	Large piece of flap
		Pieces of Radio Equipment
		Small pieces of fuselage.
	("Cu na Mara"	Ripped nets and brought up no wreckage)

27th Sept	Due to very valuable evidence recovered between 9th and 18th Sept it was decided to continue for a further eight days from 27th Sept to 4th October. Vessels employed "Cu na Mara" and "Glendalough" assisted by L.E. "Macha". Co-ordination under Lieut Deasy and Communication Party ashore. Due to weather no work was possible from Friday 27th Sept to Tuesday 1st Oct inclusive. Trawling took place on 2nd, 3rd and 4th Oct 1968, when tides forced abandonment. During this period following wreckage recovered.	
30th Sept	"Cu na Mara"	1 small piece of frame
1st October	Crew member of "Glendalough" handed up a portion of an elevator spring tab – 2' long by 8" wide – which he picked up on beach.	
2nd October	"Glendalough"	Small pieces of retractable under-carriage Pieces from engines Several pieces of panelling
3rd October	"Glendalough"	Auxiliary Cockpit seat Parts of panel control from cockpit Door frame – port side Small pieces of fuselage, pipes and wiring
	"Cu na Mara"	Heat exchanger Pieces of engine, frames fuselage and pipe
4th October	"Cu na Mara"	2 ton of Cockpit
	"Glendalough"	Small quantity pipes etc.

Operation Tuskar ended at 1625 on 4th October 1968 with landing of wreckage. L.E. "Macha" returned Base, "Glendalough" returned Kilmore Quay and "Cu na Mara" towards Dublin.

Communication and Co-ordination Party cleared up ashore on 5th Oct and returned Naval Base.

17th October	Irish Lights vessel "GRANUAILE" recovered Wreck Buoy established East of wreck site.

APPENDIX 1-1.2
Vessels engaged in Operation Tuskar
NAVAL SERVICE

Vessel	**Date Arrived**	**Date Departed**	**Remarks**
	26/3/68	30/3/68	Off Patrol from Killybegs. Took over Co-ordination of Search from HMS "HARDY"
	2/4/68	7/4//68	2nd to 4th – Surface Search 5th to 7th – Tidal Tests
	16/4/68	20/4//68	Surface Search and assisting trawler
LE "MACHA"	5/5/68	11/5/68	Do.
	19/5/68	24/5/68	Do.
	17/7/68	21/7/68	Co-ordination duties – R.N. Salvage Ships
	16/8/68	21/8/68	Do.
	9/9/68	20/9/68	Co-ordination of and assistance to trawlers
	27/9/68	4/10/68	Do.
	Total Days = 60		
	27/3/68	1/4/68	To area from leave and refit. Engaged in Surface Search
	8/4/68	13/4/68	Surface Search 8th 9th and 10th. Tidal Tests 11th Surface Search 12th and 13th
	15/4/68	16/4/68	Surface Search
LE "CLIONA"	22/4/68	26/4/68	Surface Search – Assisting trawlers
	29/4/68	4/5/68	Tidal tests 1st and 2nd May
	13/5/68	18/5/68	Tidal experiments (Meter) 16th and 17th May
LE "CLIONA"	27/5/68	7/6/68	28th, 29th, 30th May and 2nd, 3rd and 4th June. Tidal analysis – (meter) off Tuskar
(contd.)	11/6/68	22/6/68	Surface Search – Assisting Trawlers
	15/7/68	17/7/68	Co-ordination duties – R.N. Salvage Ships
	21/7/68	24/7/68	Do.
	13/8/68	16/8/68	Do.
	Total Days = 66		

ROYAL NAVY

Vessel	Date Arrived	Date Departed	Remarks
	29/3/68	20/4/68	Bottom Sonar Search
HMS SHOULTON"	9/5/68	7/6/68	Do.
	13/6/68	22/6/68	Directing "Reclaim" on to wreck and conning.
	15/7/68	18/7/68	Do.
HMS "CLARBESTON"	29/3/68	20/4/68	Diving Ship – Investigating Contacts
	9/5/68	20/5/68	
	21/5/68	29/5/68	Available in lieu of "CLARBESTON". 24th, 25th, 26th, 27th and 28th – Tidal Analysis – 2' NE of Tuskar.
C.S.V. "UPLIFTER"	13/6/68	22/6/68	Laying moorings and attending "Reclaim" on Salvage.
	12/7/68	24/7/68	Do.
	12/8/68	21/8/68	Do.
	21/5/68	24/5/68	Investigating Contacts by Diver
	29/5/68	7/6/68	Do.
HMS "RECLAIM"	13/6/68	23/6/68	Salvage operations in wreck
	15/7/68	24/7/68	Do.
	13/8/68	21/8/68	Do.
HMS "NURTON"	12/6/68	17/6/68	Bottom Sonar Search – Investigating Contacts.
HMS "BRONNINGTON"	12/6/68	15/6/68	Bottom Sonar Search – Investigating Contacts.
HMS "IVESTON"	19/7/68	20/7/68	Directing "Reclaim" on to wreck

TRAWLERS

Vessel	**Date Arrived**	**Date Departed**	**Remarks**
M.F.V. "Cu na Mara"	4/4/68	5/4/68	Tidal Experiments (Tyres)
	8/4/68	9/4/68	Preparing for Trawling
	16/4/68	26/4/68	Trawling by search of Aircraft wreck
	29/4/68	3/5/68	Do. (Winch U.S. on 3rd – returned Dublin for repairs until 16th May)
	16/5/68	7/6/68	Trawling in search of Aircraft wreckage
	12/6/68	22/6/68	Trawling in search of Aircraft wreckage clear of main wreck
	9/9/68	20/9/68	Trawling for wreckage on site of main wreck
	29/9/68	4/10/68	Do.
	Total Days=73		
M.F.V. "Glendalough"	16/4/68	26/4/68	Trawling in search of Aircraft wreckage
	29/4/68	7/6/68	Do. Main wreck located by "Glendalough" 5th June, 1968
	12/6/68	22/6/68	Trawling in search of Aircraft wreckage clear of main wreck
	9/9/68	20/9/68	Trawling for wreckage on site of main wreck
	28/9/68	4/10/68	Do.
	Total Days=81		
			Commissioners of Irish Lights Vessel
M.V. "ATLANTA"	29/4/68	5/5/68	Surface Search
	22/6/68		Laying wreck Buoy East of Main wreck
M.V. "GRANUAILE"	17/10/68		Recovering Wreck Buoy

SALVAGE OPERATIONS IN 1969

It was decided in July 1969 to continue trawling during suitable tidal conditions. One modern trawler the "Thomas McDonagh" from Kilmore Quay was employed.
The skipper of this trawler was "Billy" Bates, who when skipper of the "Glendalough" in 1968, located and brought to the surface the first piece of Viscount wreckage.

The "Thomas McDonagh" operated for 29 days during August and September 1969. When trawling, items of wreckage were recovered every day. This wreckage included one complete propeller, vertical stabilizer with rudder attached, section of starboard main spar boom, portions of baggage and radio racks, nose undercarriage bracing structure, fuselage skin and stringer sections, pieces of flap structure. On a number of occasions during the trawling periods the trawler was held fast and nets badly ripped. This occurred at the exact Decca coordinates of the wreckage location. The skipper felt he was getting caught in something big and heavy. He could not definitely say if it was aircraft wreckage or the three ton anchor or concrete clumps which were not recovered after the 1968 salvage operations.

Once he tried to lift, but the load was so heavy that it caused the trawler to list considerably, and the nets to burst asunder. The chain which he was using as a "sweep" was the only item of gear to remain intact, but that pulled free.
Trawling operations in 1969 concluded on 19th September when tidal and weather conditions became unsuitable.

Appendix 2:
Transcripts of tape recordings of R/T exchanges between EI-AOM and Air Traffic Services (Air Traffic Control Services).

Transcription from Tape Recording of communications between ALT712, EI-AOM, and Air Traffic Control, Cork Airport, Sunday 24th March 1968.

Time G.M.T.	**From**	**To**	
1026	**EI712**	**TWR.**	**712 Start.**
1026	**TWR**	**712**	**712 cleared to start, QNH 998 Temp. plus 08**
1030	**EI712**	**TWR**	**Taxi Clearance?**
1030	**EI712**	**TWR**	**TAXI?**
1031	**TWR**	**712**	**712 cleared to taxi, RW17**
1031	**TWR**	**712**	**A.T.C**
1031	**EI712**	**TWR**	**Go ahead**
1031	**TWR**	**712**	**Aer Lingus 712 is cleared Cork to London Airport airways Blue 10 Green 1 Flight level 170.**
1031	**EI712**	**TWR**	**Blue 10 Green 1 170.**
1031	**TWR**	**712**	**Your climb out will be left turn out climbing on radial 102 until through Flight Level 100 on course.**
1031	**EI712**	**TWR**	**Roger left turn out radial 102 until 100 then on course**
1031	**TWR**	**712**	**Your traffic is a Herald inbound on radial 087 estimating Youghal 46 descending to 50.**
1031	**EI712**	**TWR**	**Roger**
1032	**TWR**	**712**	**Cleared takeoff left turn out climb radial 102 wind 200/13 knots.**
1032	**EI712**	**TWR**	**Left turn out on to radial 102**
1033	**TWR**	**712**	**712 was airborne at 32 contact Approach 119.3**
1033	**EI712**	**TWR**	**Roger**
1034	**EI712**	**TWR**	**Cork Approach 712**
1034	**App.**	**712**	**Climb as instructed call passing flights level 70 please.**
1034	**EI712**	**APP.**	**Roger will call passing 70**
1035	**GWC**	**APP.**	**Cork Whiskey Charlie is passing 70**
1035	**APP.**	**GWC**	**OK Whiskey Charlie advise again out of 60**

1035	**GWC**	**APP**	**Roger will do**
1036	**APP**	**712**	**712 Present level?**
1036	**EI712**	**App**	**60 climbing to 170**
1037	**APP**	**712**	**When out of 70 712 is cleared turn left on course for Tuskar**

1037	**EI712**	**APP**	**Roger D**
1038	**EI712**	**App**	**712 out of 70**
1038	**APP**	**712**	**Roger 712 cleared on course now change to Shannon 127.5 Over**
1039	**EI712**	**App**	**Cheerio**

1120	**APP**	**EI712**	**(On 119.3) Aer Lingus 712. 712 Cork Approach calling on 121.5 disregard ______No reply**
1120	**APP**	**EI712**	**Aer Lingus 712. 712 Cork Approach calling 121.5. Do you read ---- ----- No reply**
1121	**APP**	**EI712**	**Aer Lingus 712. 712 Cork Approach calling 119.3... No reply.**

Ref:- SOX 187
Report on an Investigation into the Radio Interference experienced on 131.2 Mc/s on Sunday 24th March 1968.

1. Introduction

1.1 The transcript of the Radio Telephony Recording prepared by the Transcription Unit at Southern Divisional Office in connection with the accident to aircraft Aer Lingus 712 EI-AOM (extract Ref. No. 1., 131.2 Mc/s, period 1057 GMT to 1109 GMT on 24th March 1968), contained transactions of unknown origin that were believed to be breakthrough or radio interference. Specifically these occur on lines 14, 18, 19, 20 and 31 of the transcript.

1.2 The master tape was re-played at times prior to 1057 GMT and after 1109 GMT to ascertain if any other breakthrough or interference was present and if possible to identify the source by the callsigns used. Further interference was found at approximately 1154 GMT and forms the subject of Extract Ref. No. 2., 131,2 Mc/s, period 1053 GMT to 1057 GMT on 24th March 1968. Specifically the breakthrough occurs at lines 15 to 21 inclusive.

1.3 131.2 Mc/s is carried by three multi-carrier stations – Warlingham, Davidstow and Birdlip. Certain characteristics of the received interfering signal gave us reason to suspect that the interference was received at Birdlip rather than Warlingham or Davidstow.

1.4 The message content gave us reason to believe that the interference originated from Army stations and our Headquarters (Tels.N4(a)) were informed in order that they might investigate the source. In parallel we asked our officer-in-Charge at Birdlip to make local enquiries in an endeavour to locate the source of the interference.

2. Initial Enquiries by Officer in Charge, Birdlip

2.1 The initial approach was to a GPO employee (Mr. B. Wood) who works permanently at Birdlip and was know to be a member of the Territorial Army Volunteer Reserve and to take part in signals exercises from time to time. He confirmed that he had taken part in an exercise "in the vicinity of Birdlip" on Sunday 24th March at about the time in questions. He provided a contact who would be able to supply further details:-

Senior Permanent Staff Instructor,
Territorial Army Volunteer Reserve
Horfield Barracks,
Bristol.
Telephone – Bristol 40284

3.3 Although the interference did not now appear to originate from this unit for completeness the following details of equipment and transmissions are recorded:-

i. Frequency 5760 Kc/s
ii. Power 350 watts.
iii. Rod and wire aerials.
iv. Location of stations – Territorial Army Centre, Horfield Barracks, Bristol between two trailers some 30 yards apart.
v. Emissions:- a mixture of amplitude modulated voice (A3), C.W. W/T (A1) and F.S.K. Telegraphy (F1)
vi. Times: - 1130 – 1230 and 1400-1420 local.

3.4 In view of the frequency and power used, the distance to Birdlip – some 30 miles line of sight – the writer is also firmly of the opinion that it would not be possible for these stations to cause interference on a frequency of 131.2 Mc/s at Birdlip. This is substantiated by the fact that when the Office in Charge Birdlip initially made contact with the Territorial Army at Bristol they volunteered that they would be carrying out a similar exercise on the same frequency at 1400 local on Tuesday 2nd April 1968. On the writers instructions a listening watch was kept on the 131.2 Mc/s channel at Birdlip and no signals other than normal Air/Ground/Air transactions were heard.

3.5 Major Treseder was able to confirm however that these signals were of Army origin and were typical of an infantry unit practicing a move. The Callsigns are standard Army types and, in infantry units, are allocated a follows:-
43 – 3rd Platoon of 4th Company
90 – obsolete call for Commanding Officer’s Land Rover.
The fact that regular units do not have a fourth company in peace time, the time and date, and the use of obsolete callsigns and "sloppy" procedure indicated to him that the unit was Territorial Army.

3.6 On replaying the ¼ inch copy tape Major Treseder thought it possible that the doubtful word at line 19 of Extract Ref. No. 2 was "Stonehenge". Whilst Mr. Blackwood and the writer agreed it might be "Stonehenge" we do not wish to alter the transcript. Major Treseder pointed out that it could be a code word but he offered to check, with the Army Authority responsible for Salisbury Plain, if there were any units using the Plain on the day in question.

Only one Army unit did in fact use the Plain on Sunday 24th March 1968, and that was the 1st Worcestershire Regiment. After some difficulty the second in command of this Regiment was contacted and it was confirmed that they did not use the callsigns in question. They do not have a fourth company in peacetime. It is, of course, rather unlikely that any radio transmissions made on Salisbury Plain – some 45 miles from Birdlip could cause interference.

3.7 The writer asked Major Treseder if he could explain the Radio Telephony transactions that were attributable to the Army. Lines 15 to 21 on Extract Ref. No. 2 were stated to be typical of an Infantry Regiment practicing a move. It was though possible that no first call was heard from 43 because the stations were mobile. Turning now to Extract Ref. No. 1 the part phrase – "Charlie will you move-" at line 14 is again Army procedure the callsign Charlie should be proceeded by a numeral. The phrase "-breaking up over-" at line 18 was, in Major Tresseders opinion, a reference to breaking camp and "-on standby calling you over-" a reference to use of standby equipment to control the movement en route.
The word "-finished –" at line 31 would appear to be of Army origin although it is, of course, difficult to be certain on one isolated word.

3.8 A general discussion followed in which the writer and Major Treseder, came to the conclusion that the only possible method to trace the actual source of interference was to start with the appropriate section in Ministry of Defence (Army).

4. Summary and Conclusions

4.1 The source of the breakthrough at lines 14, 18, 19 and 20 has been shown to be of Army origin. The work at line 31 probable originates from the same source.

4.2 It was not possible to identify the actual source of the interference and if this is required it will be necessary for Tel. Headquarters (Tels. N4) to approach the Ministry of Defence (Army).

4.3 An explanation of certain words and the Radio Telephony procedures has been obtained from Officers of the Royal Signals Regiment although these were not the personnel actually making the transmission.

4.4 Subsequent to the visit to Horfield Barracks it has been ascertained that the Army do have frequency allocations in the band 41 – 68 Mc/s for low power land mobile use. This opens up the possibility of second or third harmonic interference although the source of this would have to be quite near to our receiving station. It should be noted that use of those frequencies by the Army is subject to agreement between the General Post Office and Ministry of Defence (Army).

A.L. Stratten.
Telecommunications
Civil Aviation Divisional Office.
Heston.
23rd April, 1968

Air Traffic Services,
DUBLIN AIRPORT
26th March, 1968.
EI 362 DUBLIN/BRISTOL 24th MARCH, 1968

Time	From	To	Text
1041	362	Dublin Centre	Dublin Centre good morning, 326
1041	Dublin Centre	362	Good morning, check Killiney.
1041	362	Dublin Centre	362.
1043.5	Dublin Centre	362	362, I make you at Killiney, check cruising 130.
1043.5	362	Dublin Centre	Roger 362
1053	Dublin Centre	362	If you are using the Dublin VOR it is gone off the air, you have just twelve miles to run to Vartry , on the airway centre line.
1053	362	Dublin Centre	362 Roger, just levelling now at 130.
1055.56	362	Dublin Centre	Dublin Centre Aer Lingus 362 by Vartry at 56, level 130, Strunble 05.
1056	Dublin Centre	362	Thank you very much 362, that all checks, would you change to London now please 131.2.
1056.11	362	Dublin Centre	131.2, 362 Good morning.
1056.13	Dublin Centre	362	Good Morning Gentlemen. Pleasant flight.

Certified: E.D. McConville ATCO III.

Air Traffic Services,
Shannon Airport.

Transcript of Recording of the Shannon – London telephone Line

on Sunday 24th March, 1968

Period: 1036 to 1044 (GMT

Time	From	To	Text
1036	Shannon	London	Hello One estimate Aer Lingus 712
	London	Shannon	On who? Aer Lingus 712? I have got 172. Is this 712 that's Cork to London
	Shannon	London	Cork to London. That's right
	London	Shannon	It's 712 not 172?

	Shannon	London	Yes 712
	London	Shannon	OKAY
	Shannon	London	712 is Flight Level 170 and he is Strumble at 1107
	London	Shannon	OK Thank you
1038:20	Shannon	London	Hello Sector 6. Have you any objections to the Irish 712 routing direct form Cork to Strumble?
1039	London	Shannon	None at all.
1042	London	Shannon	A westbound estimate on Speedbird 501 ….
1042	Shannon	London	Yes….
1042	London	Shannon	501 estimate Strumble 1106, 310, 465 Knots London. Green One upper Blue 10 Kennedy via Cork.
	Shannon	London	310 is the Level?
	London	Shannon	Yes
1043	Shannon	London	Hello Six a revision on Aer Lingus 712. He's estimating Strumble at 1103 and he is routing Cork direct to Strumble and I've got an estimate for you as well.
	London	Shannon	OKAY
1044	Shannon	London	It's from Dublin actually. It's Aer Lingus 362 ……..
	London	Shannon	Stand by. What was the other one?
1044	Shannon	London	It's Aer Lingus 362 a viscount. Strumble 1107 Level 130 267 Knots Dublin to Bristol. OK and the Aer Lingus 712 is routing direct to Strumble. Is that OK?
	London	Shannon	Yes that's all right
	Shannon	London	OKAY Thank you.

Aer Lingus Flight EI 712 Cork-London

On

March 24, 1968

This is a certified transcript of recording of R/T transmission on Shannon Area Control frequency 127.5 m/cs during the period 1039 to 1057 GMT inclusive on Sunday, March 24, 1968.

(signed): M. Moloney

(Senior Air Traffic
Control Officer).

Date: 25 March, 1968 Shannon Airport

Time	From	To	Text
1039:45	EI 712	Shannon	Shannon 712 good morning
	Shannon	EI 712	712 good morning
	712	Shannon	By Youghal passing through 75 climbing to 170 Tuskar 57
1040:00	Shannon	712	Roger 712 if you wish you may route direct to Strumble go ahead
	712	Shannon	(Unreadable)
	Shannon	712	Your transmission are fairly unreadable here confirm you are accepting a direct routing to Strumble
	712	Shannon	Affirmative estimating Strumble at 03.
	Shannon	712	Roger call cruising.
1041:20	Shannon	712	Your present level
	712	Shannon	712 is passing 90.
	Shannon	712	Roger arrange your climb to cross the boundary at 170.
	712	Shannon	(Unreadable).
1042:12	GAPMC	Shannon	Request permission return to Shannon flight level 100 over.
	Shannon	GAPMC	Cleared return Shannon maintain 100 report Foynes.

1043:15	EI 112	Shannon	And the 112 cruising 150
	Shannon	112	112 cleared Dublin 128.0
	112	Shannon	Cheerio
	Shannon	GAPMC	Cleared to leave 100 for flight level 55 check out of 100
	Shannon	GAPMC	Cleared to leave 100 for flight level 55 call reaching 55
1044:00	GAPMC	Shannon	Roger cleared 55 leaving 100
1045:00	GAPMC	Shannon	Foynes 80 descending over
	Shannon	GAPMC	Roger cleared VOR desc to 4,000 QNH 997 after VOR proceed out on localizer.
	GAPMC	Shannon	Roger descending to 4,000 997 will call VOR station
	Shannon	GAPMC	Cleared number 1 ILS approach runway 24 expect no delay
	GAPMC	Shannon	Roger
1047:00	GAPMC	Shannon	4,000 feet
	Shannon	GAPMC	Change to 118.7 tower will advise you of sequence
1051:48	712	Shannon	Level at 170
	Shannon	712	Roger report at Bannow
1057:07	712	Shannon	712 by Bannow level 170 estimating Strumble at 03
	Shannon	712	Roger say again the time by Bannow I got the Strumble estimate OK
	712	Shannon	57
	Shannon	712	OK time 56½ change now to London airways 131.2 good-day.
1057:29	712	Shannon	131.2

Comment: It is observed that the R/T transmissions from EI 712 were generally very poor.

No…6. Sheet No. 1 of 4 Sheets
IN CONFIDENCE

CIVIL AVIATION DEPARTMENT
Board of Trade

REASON FOR EXTRACT	Accident to aircraft – AERLINGUS 712 (EI-AOM)
GROUND STATION	London Air Traffic Control Centre
CALLSIGN	London Airways/Radar
EXTRACT REF. NO	2 (additional period prior Ext. Ref. 1.)
FREQUENCY	131.2 Mc/s.

FACILITY	AIRWAYS
TYPE OF LOG	Radiotelephony Recording
PERIOD COVERED BY EXTRACT	From 1053 GMT on 24th March, 1968.
	To 1057 GMT on 24th March, 1968

NOTES:

1. Time Signals may be injected into the recorder by the following methods:-

a. Orally by B. of T. personnel.
b. Automatically by a time injection unit in the form of three letter morse signals.

These signals may or may not occur simultaneously with speech, but for clarity the three letters are bracketed together and entered either in their correct position or immediately after the work in which the time signal occurred.

2. All time signals appearing in Column 4 are entered in Column 5, including the decode of the automatically injected signals to assist in the interpretation of the log.

3. The entries in Columns 2 and 3 have also been made to assist in the interpretation of the log and they do not necessarily occur on the recording, either in the form given or in any other form. Where they do not appear in the form given or in any form in Column 4 the entries in Columns 2 and 3 represent the opinion of the transcriber and are based on his knowledge of the recording.

4. All significant pauses in a message are indicated by a space of about half an inch. Where possible the duration of the pause is given in the "Remarks" column.

5. Words which are doubtful are indicated in Column 4 by a series of questions marks at the appropriate place. When possible the duration or number of such words and/or a probable interpretation of them is given in the "Remarks" column.

6. Works which are unintelligible are indicated in Column 4 by a series of questions marks at the appropriate place. In addition, the word "Unintelligible" and if possible the number or duration of the missing words are entered in the "Remarks" column.

F.A. Abbott
……………………………………
Officer i/c., Transcription Unit,
Southern Divisional Office, Heston

2nd April, 1968.

SUBJECT AIRCRAFT LIN 712 - SHEET NO. 2 of 4 SHEETS

OPERATION OF RECORDER Continuous - EXTRACT REF. NO. 2

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
1			D'YOU WANT THIS INBOUND LEFT ON A HEADING LONRAD OR CAN I SET		
2			HIM FREE		Intercom
3			KEEP HIM ON A HEADING IN CASE HE'S CATCHING UP THESE TWO IT'S		Intercom
4			UNLIKELY BUT THEY WOULD FEEL HAPPIER (JEC) ABOUT IT THAT WAY	1053	
5					
6			I'LL LEAVE HIM WITH YOU TO STICK HIM OVER THEN		Intercom
7					
8	LONDON RADAR	BOA 506	ER LONDON SPEEDBIRD FIVE OH SIX ON ONE THREE ONE TWO I'M OUT OF TWO		
9			FOUR ZERO CLEARED TO ONE SEVEN ZERO		
10					
11	BOA 506	LONDON RADAR	ROGER FIVE OH SIX CONTINUE ON HEADING		
12					
13	LONDON RADAR	BOA 506	ROGER		
14					
15	43	90	HELLO FOUR THREE FROM NINE ZERO LOUD AND CLEAR OVER		Breakthrough
16					
17	90	43	ER FOUR THREE HERE SIR. DID YOU WANT ME		Breakthrough.
18					
19	43	90	I'M LEAVING YOU TO QUERY THE STATE AT ??? ER OVER		(??? Doubtful word, - transmission weak.)
20					
21	90	43	ER ROGER GOING OUT THIS ROUTE ER (JED) ??? ??? ??? ??? ??? ???	1054))	Part – simultaneous, - ??? unreadable.

				)	
23			ER YOU CAN YOU GIVE ME A LEVEL ON THE SPEEDBIRD	)	Intercom
25			ER YES SPEEDBIRD TO SIX ZERO	)	Intercom.
27			THANK YOU		Intercom.
28					
29	LONDON RADAR	G-HE	ER LONDON GOLF HOTEL ECH- ECHO IS LEVEL AT ONE FIVE ZERO		
30					
31	G-HE	LONDON RADAR	ROGER HOTEL ECHO		

F.A. Abbot

OPERATIONS OF RECORDER Continuous - EXTRACT REF. NO. 2

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
33	BOA 506	LONDON RADAR	SPEEDBIRD FIVE OH SIX RADAR CONTINUE DISSENT FLIGHT LEVEL SEVEN ZERO FOR THE MOMENT		
34					
35					
36	LONDON RADAR	BOA 506	FIVE OH SIX RECLEARED TO SEVEN ZERO		
37	LONDON RADAR	G-HE	ER LONDON HOTEL ECHO DO YOU STILL WISH US TO MAINTAIN THIS HEADING		
38					
39	G-HE	LONDON RADAR	AFFIRMATIVE FOR THE MOMENT HOTEL ECHO		
40					
41	LONDON RADAR	G-HE	--TEL ECHO		"TEL" End of word.
42					
43			(JEE)	1055	Channel quiet.
44					
45			RECORDER CHECK		Maintenance injection.
46					
47	G-HE	LONDOR RADAR	HOTEL ECHO RADAR THERE’S NO RESTRICTION ON YOUR HEADING NORMAL NAVIGATION FOR WOODLEY THE Q D M IS ZERO NINE FIVE		
49					
50	LONDON RADAR	G-HE	GOLF HOTEL ECHO ROGER		
51					
52			(JEF)	1056	Channel quiet.
53					
54	LONDON AIRWAYS	JZ	ER LONDON JULIETT ZULU IS COMING UP TO BRECON IF YOU’VE NOTHING FURTHER FOR US LIKE TO Q S Y TO ER CARDIFF		

56			
57	JZ	LONDON Airways	JULIETT ZULU THAT'S AFFIRMATIVE CARDIFF ONE TWO ZERO DECIMAL SEVEN FIVE
58			
59			
60	LONDON AIRWAYS	JZ	GOOD DAY SIR
61			
62	JZ	LONDON AIRWAYS	'DAY
63			
64	TC	LONDON RADAR	TANGO CHARLIE RADAR LEVEL CHECK
65	LONDON RADAR	TC	ONE ZERO FP TANGO CHARLIE APPROACHING COMPTON
66			

F.A. Abbot.

SUBJECT AIRCRAFT LIN 712 - SHEET NO. 4 OF 4 SHEETS
OPERATIONS OF RECORDER Continuous - EXTRACT REF. NO. 2

Line	To	FROM	RECORDED INTELLIGENCE	TIME	REMARKS

No.				(GMT)	
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
68	TC	LONDON RADAR	‘KYOU		
69					
70	TC	LONDON RADAR	TANGO CHARLIE THERE’S NO RESTRICTION ON YOUR HEADING FOR WOODLEY YOUR PRESENT HEADING ??? ??? GOOD AND I MAKE YOU ER SEVEN MILES TO GO		??? Unintelligible.
72					
73	LONDON RADAR	TC	TANGO CHARLIE THANK YOU		
74					
75	LONDON AIRWAYS	LIN 326	LONDON AIRWAYS AERLINGUS THREE SIX TWO		
76					
77	LIN 362	LONDON AIRWAYS	(JEG) THREE SIX TWO AIRWAYS	1057	
78					
79	LONDON AIRWAYS	LIN 362	AERLINGUS THREE SIX TWO IS BY VARTRY AT FIVE SIX LEVEL ONE THREE ZERO STRUMBLE SERO FIVE FOR BRISTOL		
80					
81					
82	LIN 362	LONDON AIRWAYS	THREE SIX TWO ROGER ONE THREE ZERO STRUMBLE GREEN ONE BRISTOL		
83					
84	LONDON AIRWAYS	LIN 362	ROGER		

I certify that this extract, consisting of 4 sheets, each of which bears my signature, from the Radiotelephony Recording Log kept at London A.T.C.C. by the Board of Trade has been prepared under my direction and has been examined and checked by me; that Column 4 thereof is a transcription of the recording believed by me to be accurate in all respects; and that Column 5 contains a correct interpretation of the time signals appearing in code in Column 4.

F.A. Abbot : 2nd April, 1968.…………………………………………

No. 12. Sheet No. 1 of 8 Sheets

CIVIL AVIIATION DEPARTMENT
Board of Trade

REASON FOR EXTRACT	Accident to Aircraft – AERLINGUS 712 (EI-AOM)
GROUND STATION	London Air Traffic Control Centre
CALLSIGN	London Airways / Radar
EXTRACT REF. NO.	1
FREQUENCY	131.2 Mc/s.
FACILITY	AIRWAYS
TYPE OF LOG	Radiotelephony Recording
PERIOD COVERED BY EXTRACT	From 1057 GMT on 24th March, 1968.
	To 1109 GMT on 24th March, 1068.

NOTES:

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d. Automatically by a time injection unit in the form of three letter morse signals.

These signals may or may not occur simultaneously with speech, but for clarity the three letters are bracketed together and entered either in their correct position or immediately after the work in which the time signal occurred.

2. All time signals appearing in Column 4 are entered in Column 5, including the decode of the automatically injected signals to assist in the interpretation of the log.

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F.A. Abbott

……………………………………

Officer 1/c., Transcription Unit,
Southern Divisional Office, Heston

26th March, 1968.

CERTIFIED

OPERATIONS OF RECORDER Continuous - EXTRACT REF. NO. 1

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
1	LONDON AIRWAYS	LIN 362	LONDON AIRWAYS AERLINGUS THREE SIX TWO		
2					
3	LIN 362	LONDON AIRWAYS	(JEG) THREE SIX TWO AIRWAYS	1057	
4					
5	LONDON AIRWAYS	LIN 362	AERLINGUS THREE SIX TWO IS BY VARTRY AT FIVE SIX LEVEL ONE THREE ZERO STRUMBLE ZERO FIVE FOR BRISTOL		
6					
7					
8	LIN 362	LONDON AIRWAYS	THREE SIX TWO ROGER ONE THREE ZERO STRUMBLE GREEN ONE BRISTOL		
9					
10	LONDON AIRWAYS	LIN 362	ROGER		
11					
12	LONDON RADAR	TC	TANGO CHARLIE NINE ZERO		
13					
14		??	- CHARLIE WILL YOU MOVE ??? ??? ???		)Origin unknown,-)believed breakthrough.)Part – simultaneous)transmissions,)???jammed.
15					
16	TC	LONDON RADAR	ROGER TANGO CHARLIE		
17		??	??? BREAKING UP OVER ---??? --- ON STANDBY CALLING YOU OVER THAT'S BETTER THANKS ER WILL YOU TRY TO CONTACT THE TECH' IN CHARGE AT		)??? Jammed,) part –)simultaneous.

			SIGNALS ??? ??? ??? ??? ???		
18					
19					
20					
21					
22	BOA 506	LONDON RADAR	SPEEDBIRD FIVE OH SIX IS FURTHER CLEARED TO SIX ZERO WHAT'S YOUR PRESENT LEVEL		
23					
24					
25	LONDON RADAR	BOA 506	OUT OF ONE FOUR (JEH) ZERO CLEARED TO SIX ZERO	1058	)Simultaneous)transmissions,) – broke off.
26					
27		LIN 712	- ECHO INDIA ALFA OSCAR MIKE WITH YOU -		
28					
29	BOA	LONDON RADAR	THANK YOU		
30					
31		??	- FINISHED		Origin unknown.
32					
33		LIN 712	- FIVE THOUSAND FEET DESCENDING SPINNING AT RAPIDLY		Poor transmission.
34				F.A. Abbot.	

OPERATIONS OF RECORDER Continuous EXTRACT REF. NO. 1

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
35	LONDON RADAR	TC	LONDON TANGO CHARLIE		
36					
37	TC	LONDON RADAR	TANGO CHARLIE		
38					
39	LONDON RADAR	TC	ER FIVE EIGHT WOODLEY CHERTSEY AT ZERO ONE		
40					
41			FINISHED		Intercom
42					
43			YEP		Intercom
44					
45	TC	LONDON AIRWAYS	TANGO CHARLIE LONDON NOW ONE TWO SEVEN DECIMAL SEVEL		
46					
47	LONDON AIRWAYS	TC	ONE TWENTYSEVEN SEVEN GOOD DAY		
48					
49	TC	LONDON AIRWAYS	‘DAY		
50					
51	LONDON AIRWAYS	LIN 362	ER LONDON FROM AERLINGUS THREE SIX TWO		
52					
53	LIN 362	LONDON AIRWAYS	THREE SIXTY TWO GO AHEAD		
54					
55	LONDON AIRWAYS	LIN 362	ER DID YOU JUST GET THAT MESSAGE ON THAT AIRCRAFT DESCENDING FROM FIVE THOUSAND FEET SPINNING RAPIDLY OVER		
56					

LIN 362	LONDON AIRWAYS	NO WE DID'T COPY THAT WOULD YOU SAY AGAIN THE MESSAGE	
LONDON AIRWAYS	LIN 362	WE JUST RECEIVED OF A BROKEN TRANSMISSION (JEI) ERRR AIRCRAFT SPINNING RAPIDLY GOING THROUGH FIVE THOUSAND FEET ER I DIDN'T GET THE CALLSIGN IT'S – GO AHEAD	1059
LIN 362	LONDON AIRWAYS	ROGER WE HEARD A TRANSMISSION BUT ER W-W-WE THOUGHT IT WAS A BREAKTHROUGH ON THE FREQUENCY	
LONDON AIRWAYS	LIN 362	IT MAY HAVE BEEN	

F.A. Abbot.

SUBJECT AIRCRAFT LIN 712 SHEET NO. 4 OF 8 SHEETS
OPERATIONS OF RECORDER Continuous EXTRACT REF. NO. 1

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
69	LIN 362	LONDON AIRWAYS	AERLINGUS THREE SIXTY TWO YOU DIDN'T HAPPEN TO COPY THE CALLSIGN DID YOU		
70					
71					
72	LONDON AIRWAYS	LIN 362	WELL WE THOUGHT IT WAS ER OSCAR MIKE		
73	LIN 362	LONDON AIRWAYS	O K THANK YOU		
74					
75 76 77	LONDON AIRWAYS	BOA 506	ER FIVE OH SIX IT OUT OF ONE ZERO THOUSAND FOR SEVEN ZERO AND ER STILL ON THE HEADING OF ONE SIXTY AS GIVEN (KZZ) WE HEARD THE LAST PART OF HIS TRANSMISSION HE WAS DESCENDING RAPIDLY WE DIDN'T HEAR A CALLSIGN	1100	
78					
79					
80	BOA 506	LONDON	ER FIVE OH SIX ROGER THANK YOU		
81					
82	BOA 506	LONDON RADAR	FIVE OH SIX NEXT CHECK PASSING SEVEN ZERO CONTINUE YOUR HEADING FOR THE MOMENT		
83					
84					
85	LONDON RADAR	BOA 506	FIVE OH SIX		
86					
87	LONDON AIRWAYS	G-HE	ER LONDON GOLF HOTEL ECHO PASSED ER STANDNY ONE		
88					

89			I'VE FINISHED WITH HIM		Intercom
90					
91			OK		Intercom
92					
93	LONDON AIRWAYS	G-HE	ER LONDON GOLF HOTEL ECHO PASSED WOODLEY AT ZERO ONE		
94			ER FLIGHT LEVEL ONE FIVE ZERO DUNSFOLD AT ZERO SEVEN		
95					
96	G-HE	LONDON AIRWAYS	HOTEL ECHO LONDON ONE TWO SEVEN DECIMAL SEVEN		
97				F.A. Abbot	
98	LONDON AIRWAYS	G-HE	- TWO SEVEN SEVEN ROGER		
99					
100			(KZA)	1101	Channel quiet.
101					
102			RADAR YOU KNOW THAT BREAK -		(Intercom., - stopped
					(as BOA 506 called.
103					
104	LONDON RADAR	BOA 506	SPEEDBIRD FIVE OH SIX LEVELLING AT SIX ZERO		

SUBJECT AIRCRAFT LIN 712 SHEET NO. 5 OF 8 SHEETS
OPERATIONS OF RECORDER Continuous EXTRACT REF. NO. 1

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
105					
106	BOA 506	LONDON RADAR	ROGER FIVE OH SIX		
107					
108			RADAR ON THE BREAKTHOUGH DID ER YOU NOW THAT TRANSMISSION DID		Intercom
109			YOU HEAR ANYTHING ON IT AT AL ALL		
110			NO ONLY THE SPINNING BIT I DIDN'T GET ANYTHING ELSE		Intercom
111					
112			YOU GOT THE SPINNING DID YOU		Intercom
113					
114			YEAH		Intercom
115					
116			YEH O K THANK YOU		Intercom
117					
118	LONDON RADAR	TWA 705	LONDON RADAR T W A SEVEN OH FIVE WITH YOU		
119					
120	TWA 705	LONDON RADAR	SEVEN OK FIVE RADAR (KZB) FOUR THOUSAND FEET FOR THE MOMENT ADVISE	1102	
121			PASSING THREE		
122					
123	LONDON RADAR	TWA 705	ER WILL DO		
124					

125			RADAR WAS THE THE ONLY WORD YOU HEARD SPINNING	Intercom
126				
127			SPINNING AND RAPIDLY ER THAT WAS ALL	Intercom
128				
129			YES O K	Intercom
130				
131	BOA 506	LONDON RADAR	SPEEDBIRD FIVE OH SIX RADAR WILL YOU TURN LEFT FOR GARSTON NOW THE Q D M IS ZERO EIGHT ZERO	
132				
133				
134	LONDON RADAR	BOA 506	FIVE OH SIX DIRECT GARSTON THANK YOU	
135				
136	LONDON AIRWAYS	LIN 362	ER LONDON AERLINGUS THREE SIX TWO DO YOU HAVE AN AERLINGUS SEVEN ONE TWO OR SEVEN ONE THREE ON THE FREQUENCY	
137				F.A. Abbot
138	LIN 362	LONDON AIRWAYS	ER THERE’S A SEVEN ONE TWO ON	
139				
140				
141	LONDON AIRWAYS	LIN 362	ER ROGER	)Continuous

SUBJECT AIRCRAFT LIN 712 SHEET NO. 6 OF 8 SHEETS
OPERATIONS OF RECORDER Continuous EXTRACT REF. NO. 1

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
142					
143	LIN 712	LIN 362	SEVEN ONE TWO FROM ER THREE SIX TWO DO YOU READ (KZC)	1103	)) transmission.
144					
145			I DON'T THINK HE'S CALLED		Intercom
146			WE HAVEN'T GOT SEVEN ONE TWO HAVE WE		Intercom
147					
148	LIN 362	LONDON AIRWAYS	ER THREE SIX TWO THERE'S A SEVEN ONE TWO HE SHOULD CHECK STRUMBLE AT ER ZERO THREE AND IN POINT OF FACT HE HASN'T CALLED US YET		
149					
150					
151	LONDON AIRWAYS	LIN 362	ER ROGER THAT'S THE ER CALLSIGN WE THOUGHT WE HEARD OSCAR MIKE HE'S MOST LIKELY TO BE SEVEN ONE TWO		
152					
153					
154	LIN 362	LONDON AIRWAYS	ROGER YOU RECKON HIS ER OTHER CALLSIGN IS OSCAR MIKE DO YOU		
155					
156	LONDON AIRWAYS	LIN 362	ER THAT'S AFFIRMATIVE		
157					
158	LIN 362	LONDON AIRWAYS	THANK YOU		
159					
160	LONDON RADAR	TWA 705	T.W.A. SEVEN OH FIVE OUT OF THREE FOR FOUR		
161					

162	TWA 705	LONDON	ROGER SEVEN OH FIVE CLIMB TO EIGHT ZERO INITIALLY		
163					
164	LONDON RADAR	TWA 705	- K RECLEARED TO EIGHT ZERO THANK YOU		
165					
166			FIVE OH SIX ABEAM WOODLEY AND OVER		Intercom
167					
168	BOA 506	LONDON AIRWAYS	FIVE OH SIX ??? ??? ??? ???		(Poor modulation, - (??? unreadable.
169					
170	BOA 506	LONDON RADAR	ER FIVE OH SIX RADAR CONTINUE ON COURSE TO GARSTON WITH LONDON ONE ONE NINE DECIMAL TWO		
171					
172					
173	LONDON RADAR	BOA 506	ONE ONE NINE TWO (KZD)	1104	F.A.Abbot
174					
175			YOU DIDN’T GO OUT D		Intercom
176					
177	LIN 712	LONDON AIRWAYS	AERLINGUS SEVEN ONE TWO ER – AERLINGUS SEVEN ONE TWO LONDON ONE		First part very poorly
178			THREE ONE DECIMAL TWO YOU ON THE FREQUENCY		modulated.
179					

SUBJECT AIRCRAFT LIN 712 SHEET NO. 7 OF 8 SHEETS
OPERATIONS OF RECORDER Continuous EXTRACT REF. NO. 1

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
180	LONDON AIRWAYS	CAM 4097	LONDON AIRWAYS CAMBRIAN FOUR ZERO NINE SEVEN		
181	CAM 4097	LONDON AIRWAYS	FOUR ZERO NINE SEVEN LONDON		
182					
183	LONDON AIRWAYS	CAM 4097	FOUR ZERO NINE SEVEN AIRBORNE AT ER FIVE EIGHT CLIMBING TO SIX ZERO		
184			ESTIMATING BERRY HEAD THREE ONE		
185					
186	CAM 4097	LONDON AIRWAYS	ROGER IS THAT BERRY HEAD AT THIRTYONE (KZE)	1105	
187					
188	LONDON AIRWAYS	CAM 4097	ER AFFIRMATIVE FOUR ZERO NINE SEVEN		
189					
190	CAM 4097	LONDON AIWAYS	ROGER CLEARED ER CLIMBING ER ON AMBER TWENTYFIVE TO FLIGHT		
191			LEVEL SIX ZERO ER FURTHER CLIMB TO SEVEN ZERO LATER		
192					
193	LONDON AIRWAYS	CAM 4097	FOUR ZERO NINE SEVEN UNDERSTOOD		
194					
195	LONDON RADAR	TWA 705	T W A SEVEN OH FIVE OUT OF SEVEN FOR EIGHT		
196					
197			WHO WAS THAT D		Intercom
198					
199	LONDON RADAR	TWA 705	T W A SEVEN OH FIVE OUT OF SEVEN FOR EIGHT		
200					

201	TWA 705	LONDON RADAR	ROGER SEVEN OH FIVE CONTINUE THE CLIMB TO FLIGHT LEVEL TWO EIGHT		F.A.Abbot
202			ZERO NOW		
203					
204	LONDON RADAR	TWA 705	O K THANK YOU UNRESTRICTED NOW TO TWO EIGHT OH		
205					
206			(KZF)	1106	Channel Quiet
207					
208			IF YOU HAVEN’T DONE IT ALREADY YOU MIGHT SUGGEST TO AERLINGUS THE		
209			COMPANY FREQUENCY SEE IF THEY’VE GOT ANY TRACE OF THIS AIRCRAFT		Intercom.
210					
211			STANDBY RADAR PLEASE		Intercom
212					
213	LONDON AIRWAYS	LIN 362	LONDON AIRWAYS AERLINGUS THREE SIX TWO BY STRUMBLE ZERO SIX LEVEL		
214			ONE THREE ZERO AMMANFORD ONE (KZG) FIVE BRECON NEXT	1107	
214					
215					

SUBJECT AIRCRAFT LIN 712 SHEET NO. 8 OF 8 SHEETS
OPERATIONS OF RECORDER Continuous EXTRACT REF. NO. 1

Line No.	To	FROM	RECORDED INTELLIGENCE	TIME (GMT)	REMARKS
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
216	LIN 712	LONDON AIRWAYS	AERLINGUS SEVEN ONE TWO THIS IS LONDON AIRWAYS D'YOU READ		
217	LIN 362	LONDON AIRWAYS	AERLINGUS ER THREE SIX TWO WE'VE HAD NO CONTACT WITH AERLINGUS		
218			SEVEN ONE TWO YOU TRY AND GIVE HIM A CALL SHANNON HAVE NO CONTACT		
219			AT THE MOMENT THAT CALL YOU HEARD EARLIER COULD BE OF SOME		
220			IMPORTANCE OVER		
221					
222	LONDON AIRWAYS	LIN 362	ER THAT'S AFFIRMATIVE ER AS FAR AS I ER ER ER IT SEEMED TO BE VERY		
223			BROKEN ERRR WE THINK IT WAS ECHO INDIA ALFA OSCAR MIKE ER THE		
224			MESSAGE WAS HE WAS DESCENDING RAPIDLY THROUGH FIVE THOUSAND FEET		
225			SPINNING		
226					
227	LIN 362	LONDON AIRWAYS	THANK YOU VERY MUCH WE'VE TAKEN ALL THE ACTION WE CAN AT THE MOMENT		
228					
229	LONDON AIRWAYS	LIN 362	ROGER		
230					
231	LONDON AIRWAYS	LIN 362	ER THREE (KZH) SIX TWO CHECKED STRUMBLE ZERO SIX LEVEL ONE THREE	1108	
232			ZERO AMMANFORD ONE FIVE		
233					

234	LIN 362	LONDON AIRWAYS	ER THREE SIXTYTWO ROGER		
235					
236	LONDON RADAR	TWA 705	ER T W A SEVEN OH FIVE WOODLEY AT ER ZERO SIX CLIMBING WE'RE		
237			ESTIMATING LYNEHAM AT TWELVE BRECON ER MAKE THAT FOURTEEN FOR		
238			LYNEHAM		
239					
240	TWA 705	LONDON RADAR	SEVEN OH FIVE		
241					
242			(KZI)	1109	Channel quiet.

I certify that this extract, consisting of 8 sheets, each of which bears my signature, from the Radiotelephony Recording Log kept at London A.T.C.C. by the Board of Trade has been prepared under my direction and has been examined and checked by me; that Column 4 thereof is a transcription of the recording believed by me to be accurate in all respects; and that column 5 contains a correct interpretation of the time signals appearing in code in Column 4.

F.A. Abbot
………………………………

26th March, 1968
………………………………..

Appendix 3

WEATHER APPRECIATION

(Aftercast prepared by U.K. Meteorological Office)

Route: Cork-Tuskar Rock-St. George's Channel-Strumble Head.
Period: 1045-1115 GMT on 24th March, 1968.

General Situation: Pressure was low to the NW of the British Isles and high over the Continent. A SSW'ly airstream covered the whole of the British Isles. An almost stationary cold front lay just west of a line Brest – Plymouth-Tern Hill-Flamborough Head at 1100 GMT with minor waves moving quickly NNE' wards along it.

		CORK TO TUSKAR ROCK	TUSKAR ROCK TO STRUMBLE HEAD
WINDS:	Surface	180/10	180 or VRBL/10 knots
&	5000 ft.	215/20 - 5°C	210/2D - 2°C
TEMPS:	10000 ft.	220/35 - 15°C	220/30 - 8°C
	14000 ft.	220/45 - 22°C	210/60 - 16°C
	17000 ft.	210/60 – 27°C	210/70 - 23°C
	20000 ft.	210/85 - 33°C	210/85 - 30°C
WEATHER		Fair	Cloudy, Slight rain within about 15 miles of Stumble Head
SURFACE VISIBILITY		Over 30 km	8-15 km becoming 5-10 km near Strumble
CLOUD		2/8 – 4/8 Cn SC base 2000 ft. top 6000 ft. 3/8 Ac As base 12000 ft. top 15000 ft. 5/8-7/8 Ci base 25,000 ft. or above	1/8 – 3/8 S & Sc base 1000-2000 ft. top 3000-4000 ft. increasing to 5/8 – 7/8 near Strumble. 8/8 Ca base 20,000 ft. or above with 7/8 – 8/8 As base 12,000 ft. top 15,000 ft. thickening towards Strumble to 8/8 base 10,000 ft. top 17,000 ft.
HEIGHT OF 0°C ISOTHERM		3000 ft.	4000 ft.

	CORK TO TUSKAR ROCK	TUSKAR ROCK TO STRUMBLE HEAD
AIRFRAME ICING	Slight	Slight, possibly moderate in cloud below 13,000 ft. near Strumble.
TURBULENCE	Slight	Although turbulence cannot be ruled out, it seems unlikely that it would have been exceptional.
THUNDERSTORMS	There is no evidence of Cumulonimbus development over the route and the possibility of any thunderstorm is considered to be virtually nil.	

APPENDIX 4 (a) - AIRFRAME & EQUIPMENT.

Wreckage analysis report on the Aer Lingus Viscount 803, Registration No. EI-AOM which crashed on 24th March, 1968 near Tuskar Rock.

Contents

Section 1 – Introduction

The Wreckage analysis was carried out in No. 3 Hangar at Casement Aerodrome and facilities were provided for washing down the wreckage and treating where necessary to inhibit corrosion.

The majority of the floating debris was recovered during the period 25th to 30th March 1968. This consisted of:- the port main wheels attached to the inner cylinder; pieces of the centre aisle balsa core floor; some seat cushions; carpeting; a few life jackets; personal effects and other items from the cabin interior.

It was almost three months after the accident before the main wreckage site was pin-pointed by the recovery of the fuselage structure over the rear entry doors, and in the ensuing fifteen months the remainder of the wreckage was recovered at various times when the weather and tides were suitable.

The damage caused by immersion in the sea was readily apparent and did not in general hamper the investigation. It consisted of corrosion, marine encrustation, and some polishing and scoring on the lighter pieces. The extent of the damage varied widely depending on the material, protective treatment and time in the sea. With the exception of a few isolated areas the general airframe structure was little effected but corrosion was very evident on the passenger seat rails and all of the magnesium components (i.e. engine casings, some control run items, wheel hubs and portions of the passenger seats.) This varied from deep pitting and holing to complete disintegration.

An initial survey of the weckage did not produce any indication as to the probable cause of the accident and to assist the investigation it was decided to reconstruct the airframe.

Identification of the weckage was time consuming. Some of the pieces were easily placed because of the local structural variations at doors, windows, fairings, etc. and others by the external paint scheme. However, in a number of cases it was necessary to make on the spot comparisons with similar aircraft. A large number of the smaller pieces could not be accurately placed and were only identified as belonging either to the wings or fuselage or some other component.

The wings including flaps, ailerons, nacelles and undercarriage were reconstructed as completely as possible. The fuselage was severly fragmented but because of the small amount recovered it was possible to carry out the investigation without recourse to a three-dimensional build up.

The items recovered in the tail area were the upper two-thirds of the fin and rudder, the rudder torque tube, portion of the tabs from the rudder and elevators and about three square feet of rudder skin. The tailplanes, elevators and the fuselage structure in the tailcone area were not recovered.

Section 2 - Wing Box Structure.

2.1. Introduction. The wings were severely damaged but fragmentation was not generally as severe as on the fuselage. The structure recovered and the salient features of the damage are shown in Figs 2.1. and 2.2. Pieces of the trailing edge shroud structure were also recovered, some loosely attached to the wing. A large amount of the wreckage was contained in five pieces:-

The central area of the main spar attached to the fuselage frame with lower port boom intact out to the outer engine;

The port wing from stn. 50 to stn. 230 with the port undercarriage and mounting structure attached;

The port wing from stn. 230 to the tip rib stn 517;

The stb'd wing from stn. 96 to stn. 320 with the stb'd undercarriage and mounting structure attached;

The stb'd wing almost complete from stn. 420 to the tip.

In addition many other pieces annotated in figs. 2.1 and 2.2. had broken away and were recovered separately. It will be noted that about 70% of the wing box structure was recovered and this included almost all of the main spar.

A survey of the wreckage pointed clearly to the fact that in-flight failure of the wing box structure did not occur. All of the structure recovered was in the main impact area and the damage from tip to tip was consistent with the wings being attached to impact. The general impression created was that large up and rearward forces had at some time during impact been applied to the lower surface. The fuel tanks had been ripped apart and remnants of the tank sheeting and bladders were attached to the wing structure. The outer portion of the stb'd wing was broken away between stn. 430 and 460 and was recovered in one piece with only moderate impact damage.

It should be noted here that most of the wing bending strength is concentrated in the main spar and the damage to this was caused more by overall bending rather than local impact loads. The remainder of the structure is comparatively light and more subject to damage under local impact and inertia effects and would thus not necessarily reflect the overall failure mode of the wing.

2.2 (Ref. Fig. 2.2.) Lower Wing Skin. Large up-impact forces had in general forced the lower skin hard up into the wing, tearing it away around the periphery and causing fragmentation. Formers and reinforcing were still attached to the items recovered.
The skin at the leading edge between engines 3 and 4 and adjacent to the fuselage on the port side had been rolled up and pushed aft against the leading edge member. Damage local to the wing tips was less pronounced and the skin was still attached.

2.3. (Re. Fig. 2.2.) Upper Wing Skin. With the exception of a few pieces the upper skin recovered was still loosely in position. It was torn around the edge, bowed up and buckled and this was caused primarily by a follow through of the impact forces on the lower skin. Nothing of the skin was recovered between stn. 320 and 430 and it was apparent that severe fragmentation had taken place in this area.

2.4. (Ref. Fig. 2.1.) Leading Edge Member. The Leading Edge member had fractured into a number of segments, some still in position in the wing, and others broken away with the nacelle or pieces of fuselage structure. The outer wing joints and those to the fuselage frame were intact. The damage was influenced largely by local impact forces, necelle loads and wing fuselage interaction effects. The portion between engines 3 and 4 had been bowed up and twisted and the wing skin locally had been rolled up and forced aft against it. This was also apparent on the pieces adjacent to the fuselage side.

2.5. (Ref. Fig. 2.1.) Trailing Edge Member. Most of the trailing edge member recovered was in position and had been shielded to some extent from direct impact forces. The damage is shown in Fig. 2.1 and it may be noted that the positions of the fractures were compatible with those on the main spar.

2.6. (Ref. Fig. 2.1.) Ribs. The ribs recovered were in position in the wing with the exception of the forward half of rib 96 on the portside which was recovered separately attached to a portion of the leading edge member. Damage varied, some of the light ribs recovered were torn and crushed by local impact loads, but there was evidence that at least over the flap area the ribs had experienced high downward inertia loads from the trailing edge and this is confirmed by the flap beams. The loads from the front in the region of engines 2, 3 and 4 were aft and upwards but there was evidence of aft and down loads on the fwd. half of rib 257 port side.

2.7. (Ref. Fig. 2.1.) Main Spar. The structure recovered and the salient damage are shown in Fig. 2.1 and detailed examination revealed no signs of fatigue or pre-impact damage of any sort.

The fractures at stns. 419, 323 and inb'd of stn. 96 on the stb'd wing had all the characteristics of failure caused by upwards bending. Most of the spar on this side was still contained by the surrounding structure, the exceptions being the root area and the portion between 323 and 419. Over this area the wing had been completely disrupted and the portion of the spar shown was recovered separately.

The fractures on the port wing are more complex. The web tear and top boom failure at the wing root was caused by upwards bending but the fracture at stn. 236 particularly on the lower boom exhibited characteristics of failure due to downwards bending, also the top boom inb'd of this fracture was bowed down. It is reasoned from this that at initial impact a large portion of the port wing was clear of the water and since the outer tanks were full of fuel the ensuing downwards bending due to inertia forces caused the failure at stn. 236 and the follow through arrested by upward impact forces caused most of the damage to the port wing.

The rivet shear failure directions on the port lower boom are illustrated in Fig. 2.1. Subsequent to the wing failure at stn. 236 impact loads probably initiated the tearing away of the web from the lower booms in an upwards direction, the change over to outwards failure is consistent with a tension build up in the lower boom caused by upward bending which led to failure of the web and top boom at the fuselage side. The downwards shear between 96 and 131 was probably due to high undercarriage inertia loads.

Over the fuselage area the web was torn and forced back by aft impact loads and damage was severe outb'd of 370 on the port side and between 323 and 419 on the stb'd side. All joints on the spar were intact.

<u>2.8. Summary of Conclusions</u>. About 70% of the wing box structure including most of the main spar was recovered all in the main wreckage area thus eliminating any possibility of complete in-flight failure. Detailed analysis of the fractures and the general distortion did not reveal any evidence of fatigue or anything to suggest unusual in-flight wing distortion or overload conditions. The damage from tip to tip was

consistent with the wings being attached at impact and there were no signs of fire or explosion having occurred in the nacelle area or anywhere else on the wings.

The failure mode throughout the stb'd wing was upwards. The fracture at stn. 236 on the port main spar was down but subsequent to this the complete port wing had been subjected to high up impact loads.

Evidence from the port undercarriage and mounting structure also suggested the presence of downward inertia loads, prior to impact. It would appear therefore that the stb'd wing was low at impact. Evidence from the flap beams and wing supporting ribs on both sides indicated down inertia effects and for this to happen the aircraft must have been in a nose down attitude at impact.

Taking all the facts into account the best estimate of the aircraft attitude at impact is:-

Stb'd wing 6º to 10º low
Nose down 10º to 20º

There was no evidence to suggest the presence of any appreciable rolling or yawing at impact but the aircraft was obviously descending rapidly with moderate or low forward speed.

Attached Diagrams

- Fig 2.1
- Fig 2.2

Fig 2.1

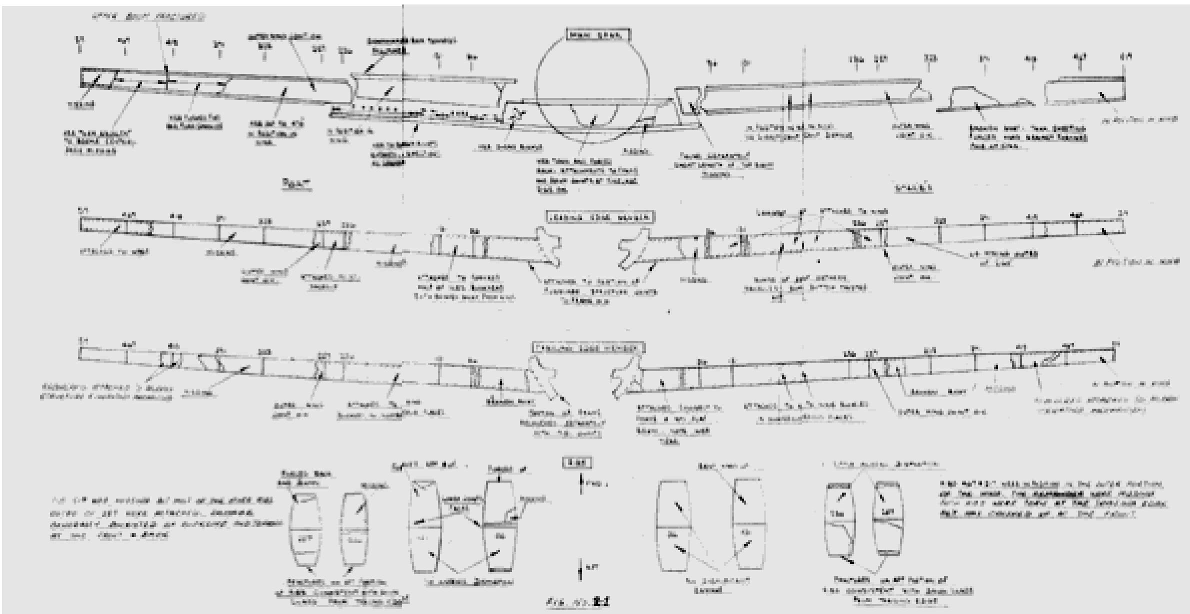
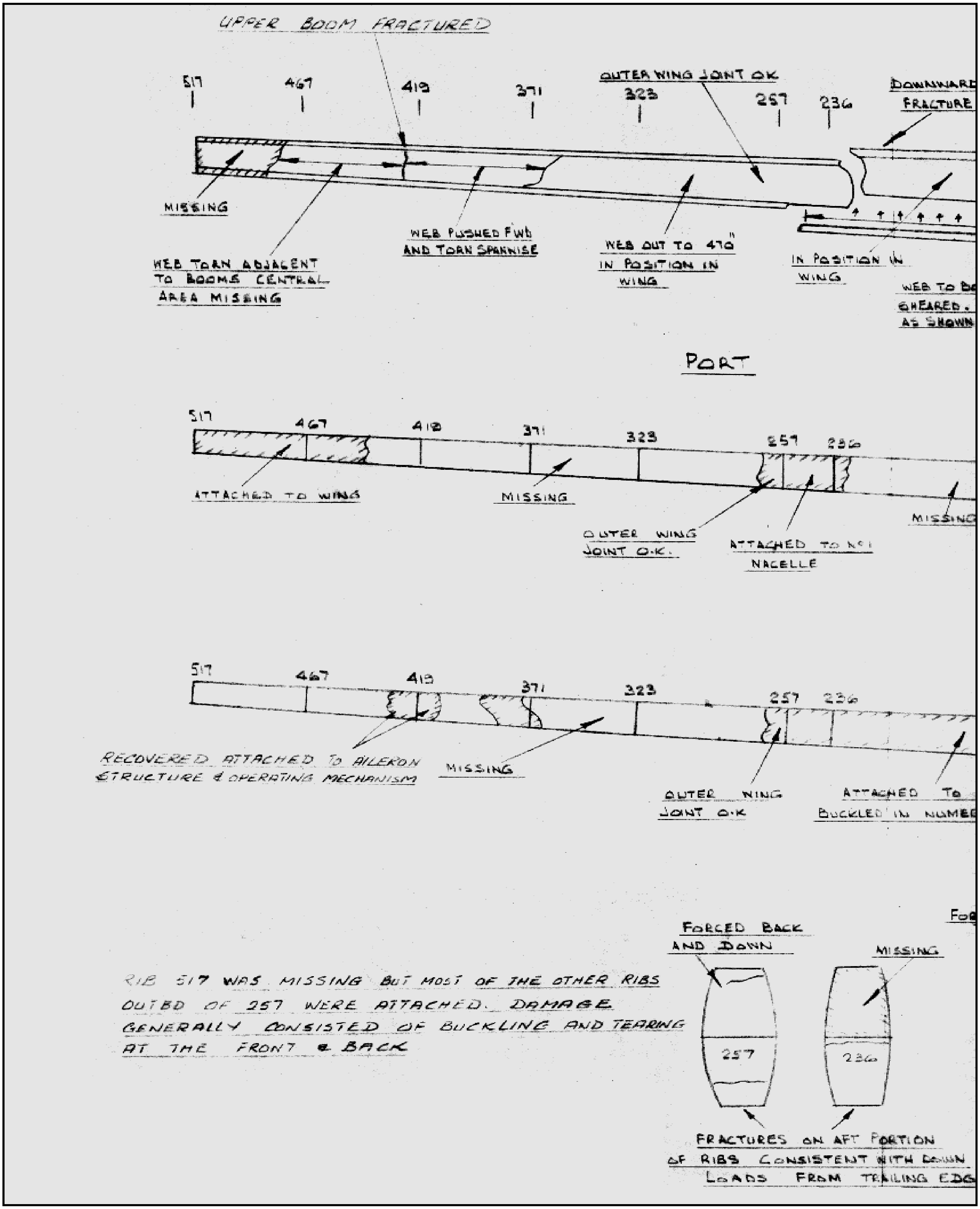


Fig 2.1 - Part A | Fig 2.1 - Part B | Fig 2.1 - Part C



UPPER BOOM FRACTURED
517
467
419
371
OUTER WING JOINT OK
323
257
236
MISSING
WEB TORN ADJACENT TO BOOMS CENTRAL AREA MISSING
WEB PUSHED FWD AND TORN SPANWISE
WEB OUT TO 470" IN POSITION IN WING
IN POSITION IN WING
PORT
ATTACHED TO WING
MISSING
OUTER WING JOINT O.K.
ATTACHED TO No 1 NACELLE
RECOVERED ATTACHED TO AILERON STRUCTURE & OPERATING MECHANISM
MISSING
OUTER WING JOINT O.K
RIB 517 WAS MISSING BUT MOST OF THE OTHER RIBS OUTBD OF 257 WERE ATTACHED. DAMAGE GENERALLY CONSISTED OF BUCKLING AND TEARING AT THE FRONT & BACK
FORCED BACK AND DOWN
MISSING
257
236
FRACTURES ON AFT PORTION OF RIBS CONSISTENT WITH DOWN LOADS FROM TRAILING EDG

Fig 2.1 - Part A

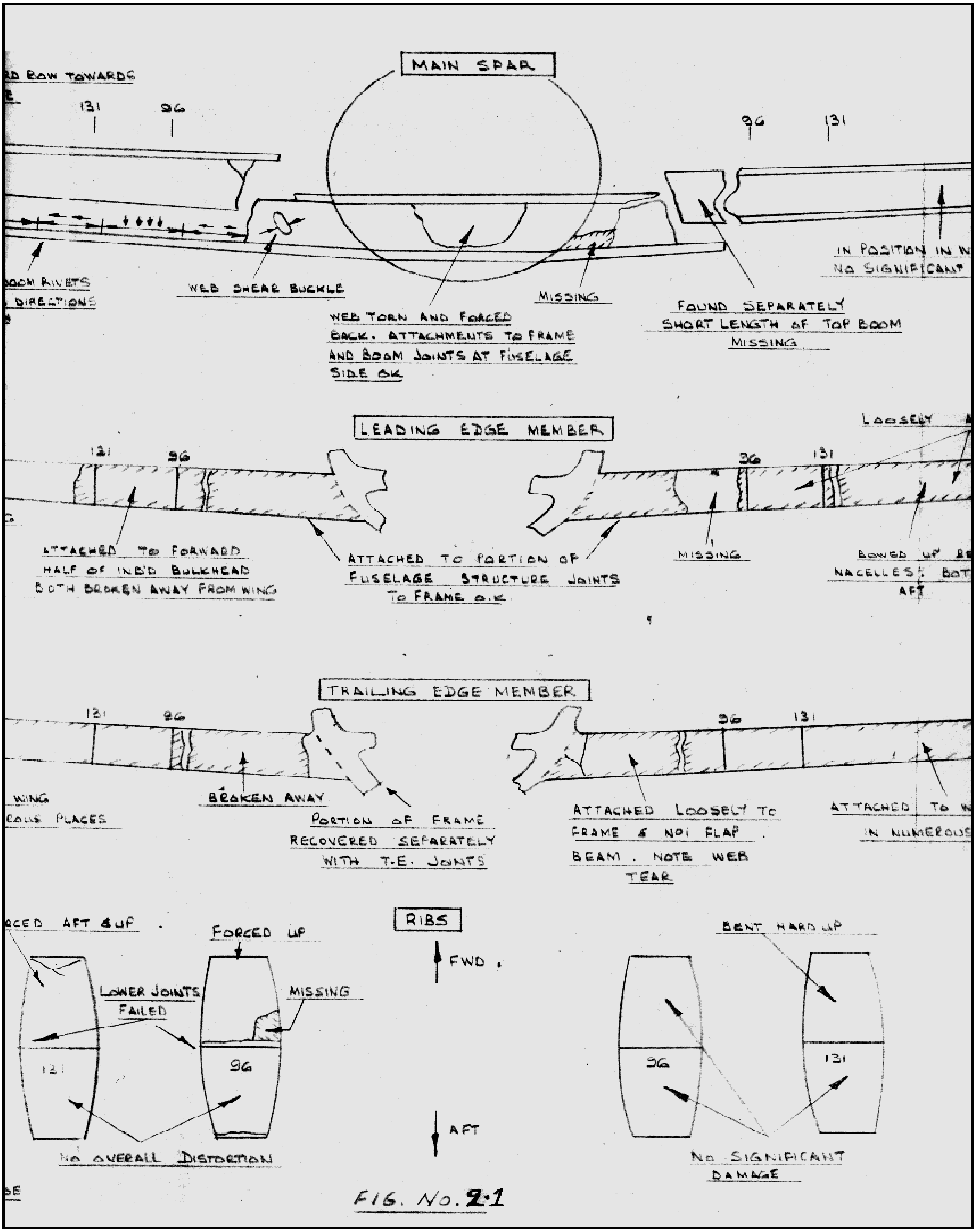

MAIN SPAR
RD BOW TOWARDS
131
96
OOM RIVETS
DIRECTIONS
WEB SHEAR BUCKLE
MISSING
WEB TORN AND FORCED BACK. ATTACHMENTS TO FRAME AND BOOM JOINTS AT FUSELAGE SIDE OK
FOUND SEPARATELY
SHORT LENGTH OF TOP BOOM MISSING
IN POSITION IN W
NO SIGNIFICANT
LEADING EDGE MEMBER
LOOSELY
ATTACHED TO FORWARD HALF OF INB'D BULKHEAD
BOTH BROKEN AWAY FROM WING
ATTACHED TO PORTION OF FUSELAGE STRUCTURE JOINTS TO FRAME O.K.
MISSING
BOWED UP BE
NACELLES & BOT
AFT
TRAILING EDGE MEMBER
WING
OUS PLACES
BROKEN AWAY
PORTION OF FRAME RECOVERED SEPARATELY WITH T-E. JOINTS
ATTACHED LOOSELY TO FRAME & NO1 FLAP BEAM. NOTE WEB TEAR
ATTACHED TO W
IN NUMEROUS
RIBS
RCED AFT & UP
FORCED UP
LOWER JOINTS FAILED
MISSING
FWD.
AFT
BENT HARD UP
NO OVERALL DISTORTION
NO SIGNIFICANT DAMAGE
SE
FIG. No. 2·1

Fig 2.1 - Part B

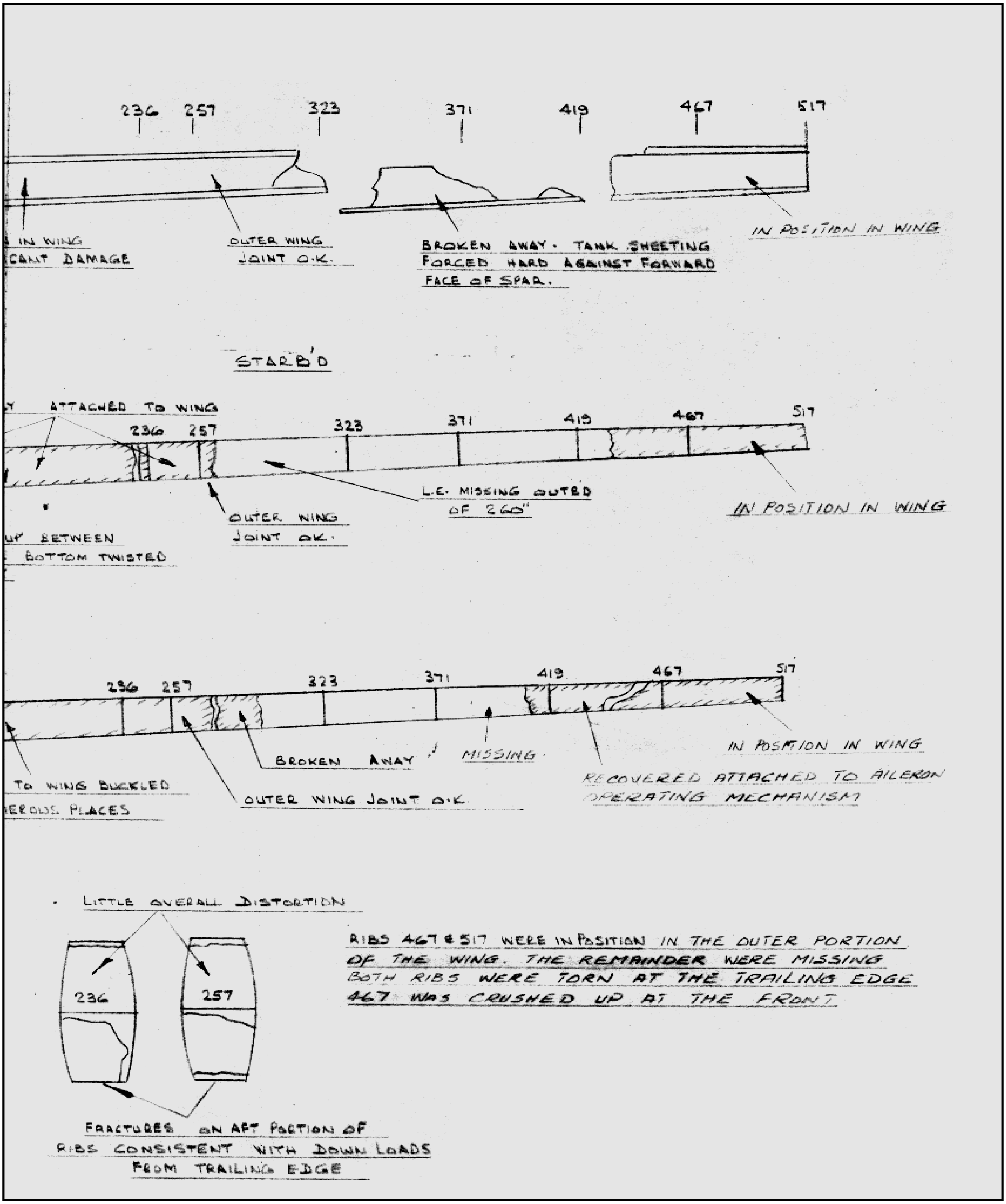

236
257
323
371
419
467
517
IN WING
CANT DAMAGE
OUTER WING
JOINT O.K.
BROKEN AWAY. TANK SHEETING
FORCED HARD AGAINST FORWARD
FACE OF SPAR.
IN POSITION IN WING
STARB'D
ATTACHED TO WING
L.E. MISSING OUTBD
OF 260"
OUTER WING
JOINT OK.
UP BETWEEN
BOTTOM TWISTED
IN POSITION IN WING
BROKEN AWAY
MISSING.
IN POSITION IN WING
TO WING BUCKLED
EROUS PLACES
OUTER WING JOINT O.K
RECOVERED ATTACHED TO AILERON
OPERATING MECHANISM
LITTLE OVERALL DISTORTION
RIBS 467 & 517 WERE IN POSITION IN THE OUTER PORTION
OF THE WING. THE REMAINDER WERE MISSING
BOTH RIBS WERE TORN AT THE TRAILING EDGE
467 WAS CRUSHED UP AT THE FRONT
FRACTURES ON AFT PORTION OF
RIBS CONSISTENT WITH DOWN LOADS
FROM TRAILING EDGE

Fig 2.1 - Part C

Section 3 – Wing Flaps

The wing flaps and items of the drive system recovered are shown in Fig. 3.1. The D.C. drive motor and gear-box are missing. The emergency motor was recovered. It had broken clear of the gear-box but the bevel drive gear and the electrical leads were still attached.

Torque Tube Drive Some inner lengths of the torque tube were recovered, about 35% of the total. The segments separated by failing the splined joints at the beams and joints on either side of the guide brackets. The general mode of failure was bending. The segment of torque tube in the fuselage separated at the outer bolted joint end fitting and was attached to the pressure seal and a portion of the fuselage skin.

The torque tube had pulled clear of the two outer guide brackets leaving them intact and still attached. The inner two were attached to the torque tube and broken away from the trailing edge.

Flap beams and mechanisms. Five of the eight flap beams were recovered complete with chain boxes, jockey sprockets, guide rollers, chains and sliders. They were complete but had broken away from the wing in the region of the joints at the trailing edge member. The general direction of failure was downwards.

The inb'd slider on the number two port beam was broken away from the chain but otherwise the chains and sliders were intact. The flap drive spigots located were attached to sliders and/or flap end ribs. The over-travel micro-switches on the No. 1 flap beam were attached.

The sliders were located 6" to 7" aft of the zero flap angle position with the exception of the slider on the No. 1 stb'd beam which had only moved aft a distance of 3".

The guide rails and/or the supporting structure were damaged in the region of the zero flap angle positions clearly indicating that the flaps were retracted at initial impact. The aft movement was probably caused by the induced nose up pitch after initial impact.

Telescopic tie-rods. Five of the telescopic tie-rods were recovered including the lockable ones on the No. 2 flap beams. The No. 1 stb'd tie-rod was broken at the aft end, but the remaining four, although bowed were unbroken and had extended an amount roughly compatible with the slider positions.

The lockable coupling was broken on the port side but intact and unlocked on the stb'd side. The forward attachments to beams and aft attachments to the cross shaft were intact but the cross shafts were torn clear of some of the flap end ribs.

Flaps. The items of flap structure recovered are shown in Fig. 3.1. The most severe damage to the flaps occurred at the leading edge and in the region of the end ribs, in a number of cases breaking away both slats and end ribs.

Pedestal controls. Main flap selector in the flaps up position. Main motor trip and reset switch in the neutral position. Emergency engage switch wire locked to the normal position. Emergency selector switch in the centre (off) position.

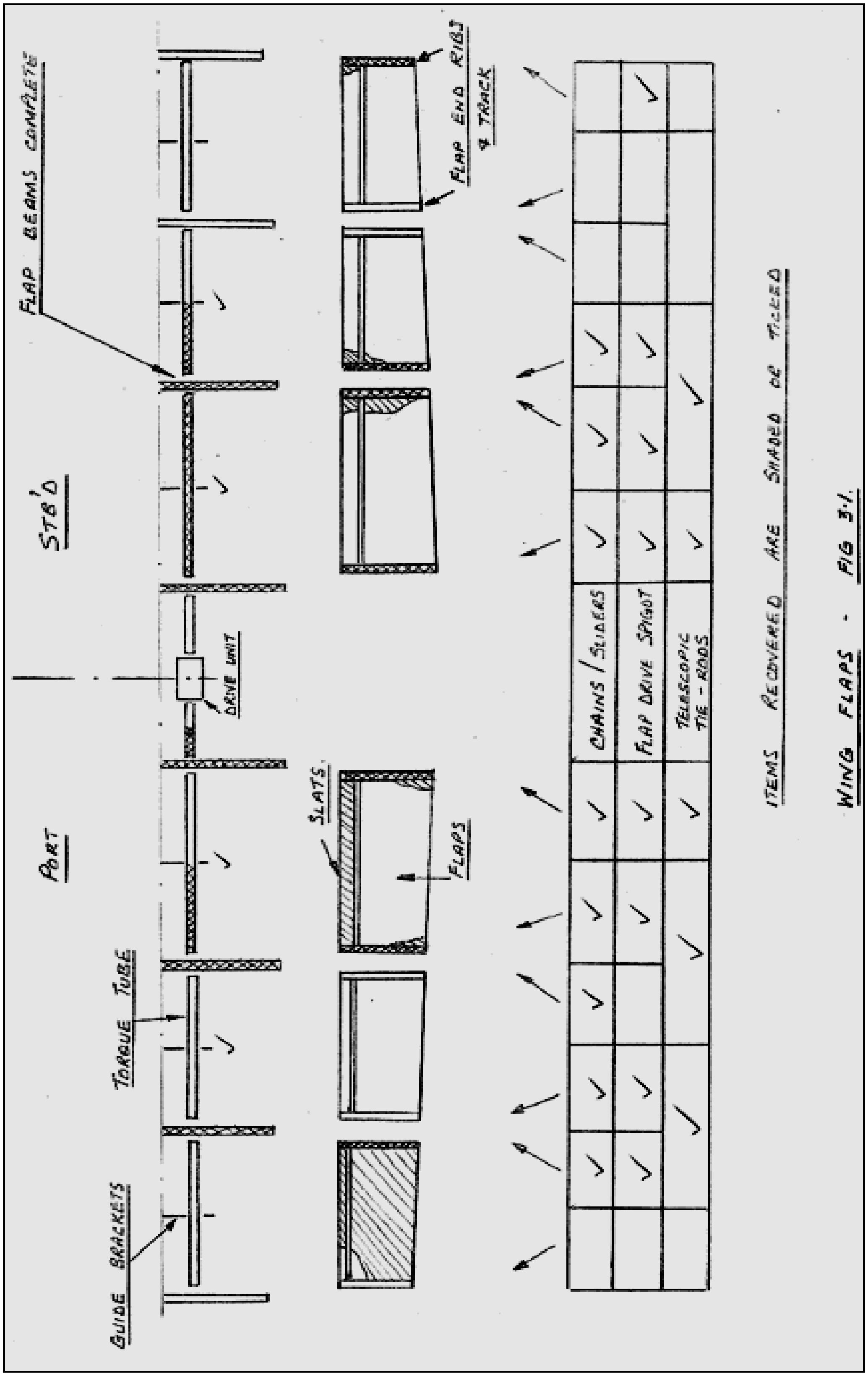
Summary of conclusions. The pedestal controls indicate that the flaps were fully retracted at impact and this is confirmed by damage on the flap beams.

Examination of the wreckage revealed no signs of fatigue, overload, or malfunction having occurred in flight but there is sufficient evidence to say that the system was intact at impact.

The flap beam joints at the trailing edge member were disrupted by loads in a downwards direction caused by inertia effects on the flaps and flap beams at impact. It is probable that the aircraft struck in a nose down attitude with the flaps clear of the water.

Attached Diagrams

- Fig 3.1



Wing Flaps - Fig 3.1

Section 4 Engine Nacelle.

A large proportion of the four nacelles was recovered. These were pieced together in their relative positions on the airframe mock-up and studied. Refer to Figs. 4.1., 4.2., 4.3. which shows the tabular structure recovered and the damage.

Nacelle No. 1. The engine had broken away from the nacelle by failing the bolts attaching the mounting brackets to the casing. The nacelle structure had parted from the wing and was recovered in one piece comprising: the tubular structure shown in Figs. 4.1 and 4.2., the firewall mounted in position with exhaust assembly, a portion of the wing L.E. member attached to the top tubes, most of the top and some of the side nacelle panels. The jet pipe and shroud, frame and tube joints below the wing L.E. were missing.

The top of the nacelle was in good condition, but the bottom inb'd side of the firewall and associated tubular members were severely damaged. The actual impact loads were essentially upwards and aft and it was noted that the damage was more severe at the lower inbound corner.

Nacelle No. 2. The nacelle structure had completely separated between the firewall and the wing L.E. and was recovered in two pieces. The forward portion consisting of: firewall, exhaust assembly shroud, tubular structure forward and aft of the firewall, and small pieces of macelle skinning were loosely attached to the engine. A number of bolts attaching the engine mounting brackets to the casing were broken. The aft portion of the nacelle which included some tubular structure, jet pipe and shroud and the frame at the L.E. was attached to a large portion of the local wing structure (L.E. member and inboard forward wing rib).

It was obvious that the nacelles had been subjected to large upwards and some aft impact loads. The firewall was pushed back at the lower end, the jet pipe was crushed flat and the frame at the L.E. had been forced backwards and upwards breaking clear of the tubes at the outer joint.

Nacelle No. 3. This nacelle had also separated between the firewall and wing L.E. The frame at the L.E. and the jet pipe and shroud were missing and bits of the tubular structure were attached to the large portion of stb'd wing recovered. The forward portion of the nacelle was recovered loosely attached to the engine and comprised the firewall mounted in position with exhaust assembly, tubular structure f'wd and aft of the firewall and small pieces of nacelle skinning. Some pieces of the tubular structure were recovered separately. The firewall was badly damaged by aft impact loads and it was apparent that the bottom of the nacelle had been subjected to large upward and aft impact loads. Damage was more pronounced at the outb'd side.

Nacelle No. 4. This nacelle was more severely damaged than the outb'd one on the port wing and again the engine had broken away by failing the bolts attaching the mounting brackets to the casing. The forward part of the nacelle was recovered broken away from the wing and includes the firewall mounted in position with exhaust assembly shroud, some tubular structure forward and aft of the firewall and pieces of the nacelle skinning. The lower tubes on the outb'd side were recovered separately with a portion of the L.E. frame, and bits of the tubular structure were still attached to the wing. The portion of the nacelle on the wing was distorted down and out. The bottom of the firewall was bent aft and badly damaged, more severely on the outb'd side and the nacelle had been subjected to up and aft impact loads.

Summary of Conclusions

The loads at impact would be: rotational, aft and up impact loads on the propeller blades and engines, inertia and impact loads applied directly to the nacelles, and interaction loads between the wings and nacelle.

The initial impact loads would be the rotational, aft and upward forces applied to the propeller and front of the engine and the damage to the tubular structure forward of the firewall would reflect the nature of these loads. Refer to Fig. 4.1. which compares this structure on the four engines. The top tubes were undamaged on all four and the general direction of engine separation from the mounting brackets was aft in all cases. The varying damage to the side and lower tubes could easily be explained by (1) rotational forces (2) the angle of the first propeller blade to hit the water (3) inner propellers lower and forward of outer propellers.

It was obvious that the bottom of both nacelles had been subjected to high up and some aft impact loads. The damage to the stb'd outer nacelle was more severe than on the outer port nacelle. This is logical if we assume that the stb'd wing was slightly lower than the port and this is indeed confirmed by evidence from the wing.

A detailed examination of all nacelle structure recovered revealed no evidence of fire, explosion, fatigue or pre-impact failure of any sort. The numerous tube tractures were generally caused by bowing and bending.

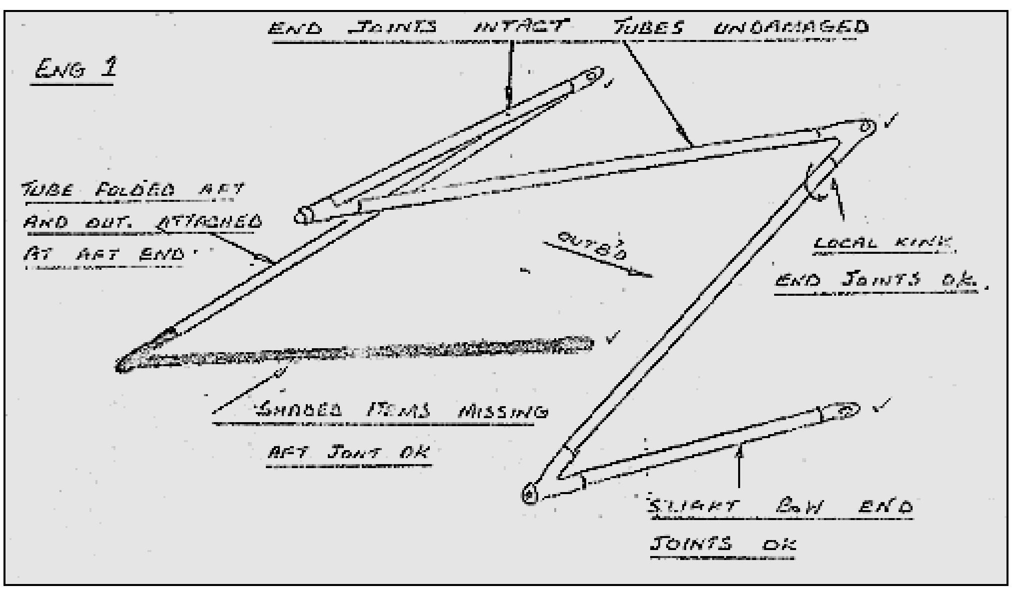
In conclusion the following facts are summarised:-

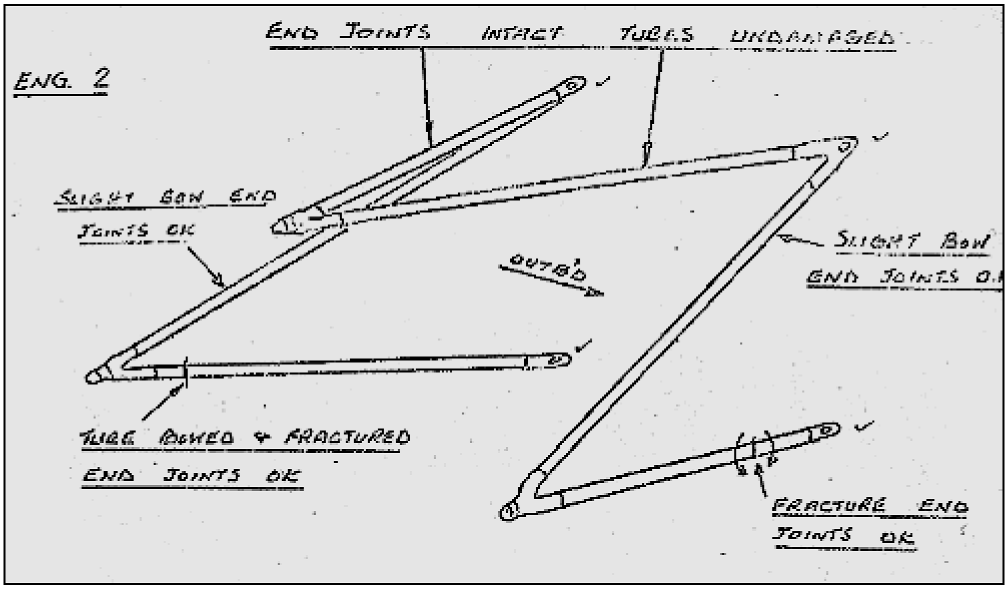
1. Comparison of the damage to the forward engine support structure on the four engines suggests that all engines and propellers were mounted in position at impact and operating approx. under the same power setting.
2. No evidence of fire, explosion, fatigue or pre-impact failure of any sort.
3. The damage would suggest that at impact the downward velocity was high, forward velocity moderate and that the aircraft impacted fairly flat with nose and stb'd wing slightly down.

Attached Diagrams

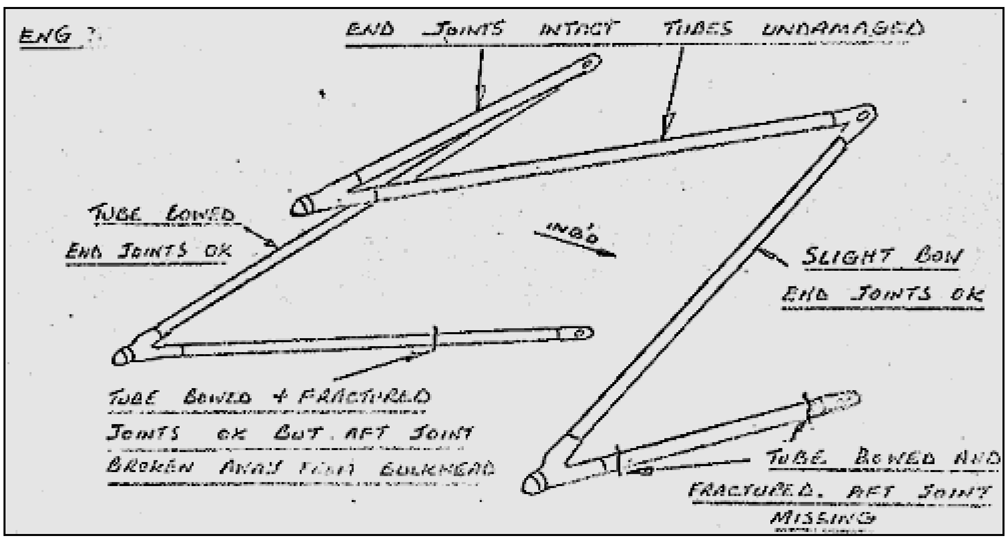
- Fig 4.1
- Fig 4.2
- Fig 4.3

Fig 4.1 - Forward Engine Support Structure (Items missing are shaded)

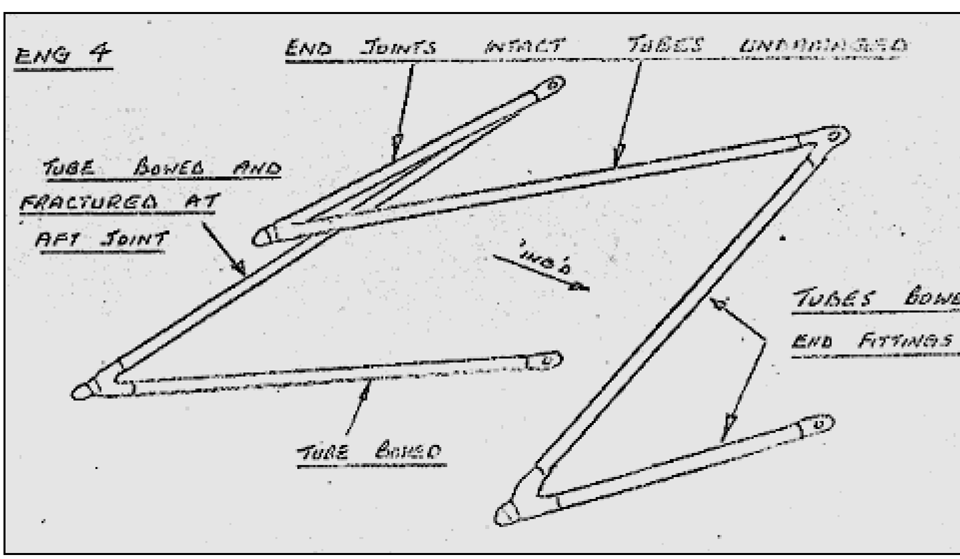




ENG. 2
END JOINTS INTACT TUBES UNDAMAGED
SLIGHT BOW END JOINTS OK
OUTB'D
SLIGHT BOW
END JOINTS O.
TUBE BOWED + FRACTURED
END JOINTS OK
FRACTURE END JOINTS OK

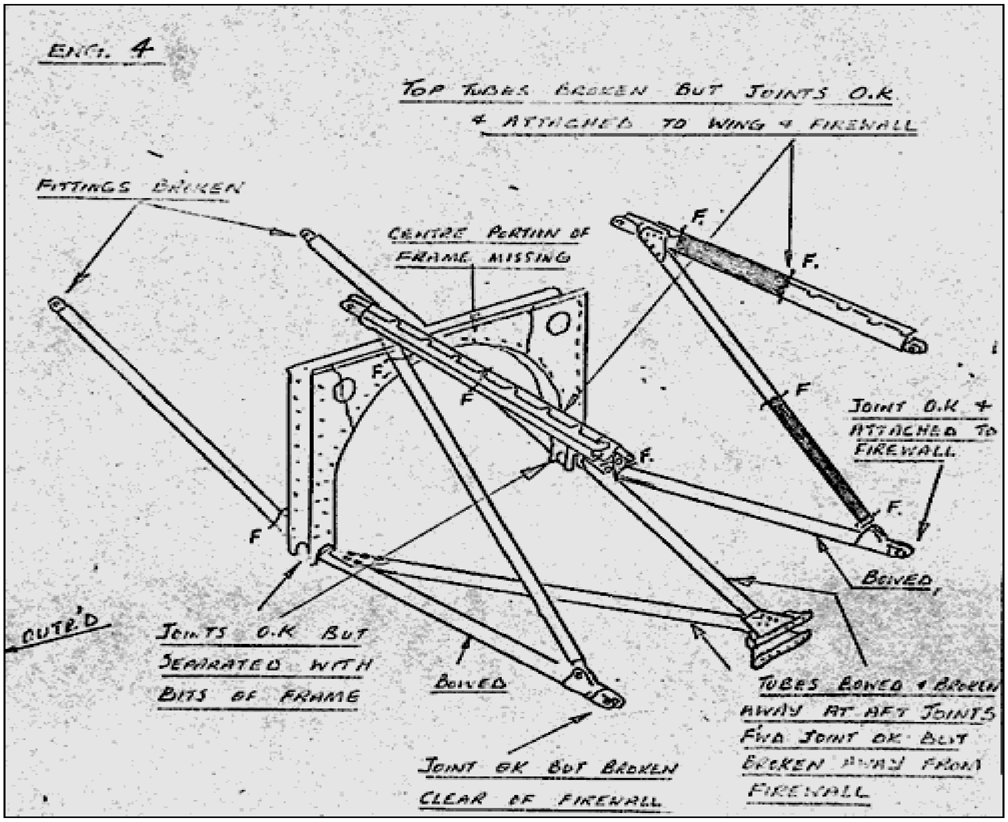


END JOINTS INTACT TUBES UNDAMAGED
TUBE BOWED
END JOINTS OK
INB'D
SLIGHT BOW
END JOINTS OK
TUBE BOWED + FRACTURED
JOINTS OK BUT AFT JOINT
TUBE BOWED AND
FRACTURED. AFT JOINT
MISSING



ENG 4
END JOINTS INTACT TUBES
TUBE BOWED AND
FRACTURED AT
AFT JOINT
INB'D
TUBES BOWED
END FITTINGS O.
TUBE BOWED

Fig 4.2 - Tubular Structure Outer Nacelles (Items missing are shaded) - F = Fracture



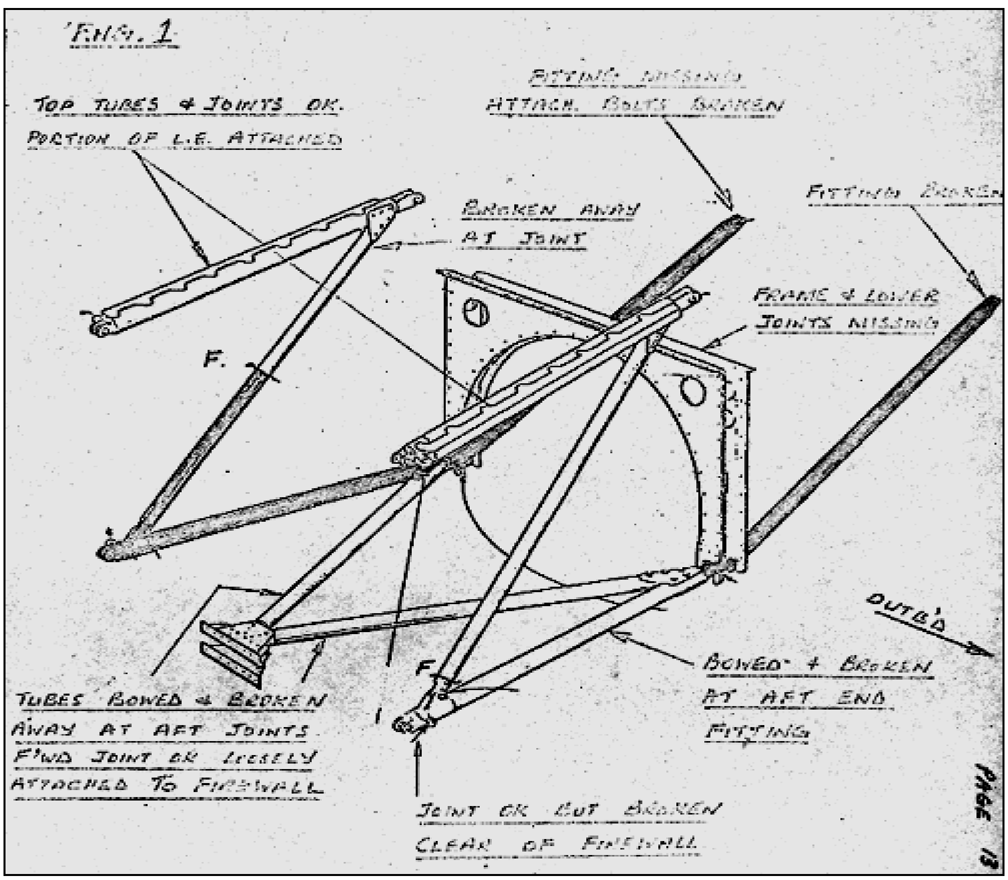
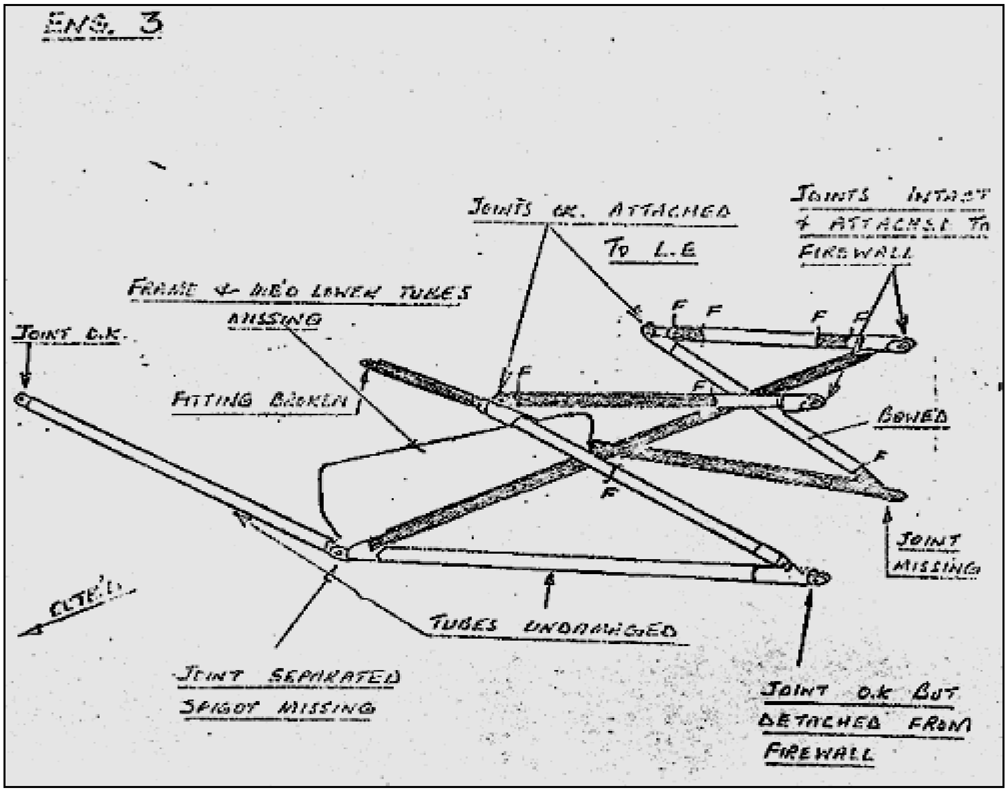
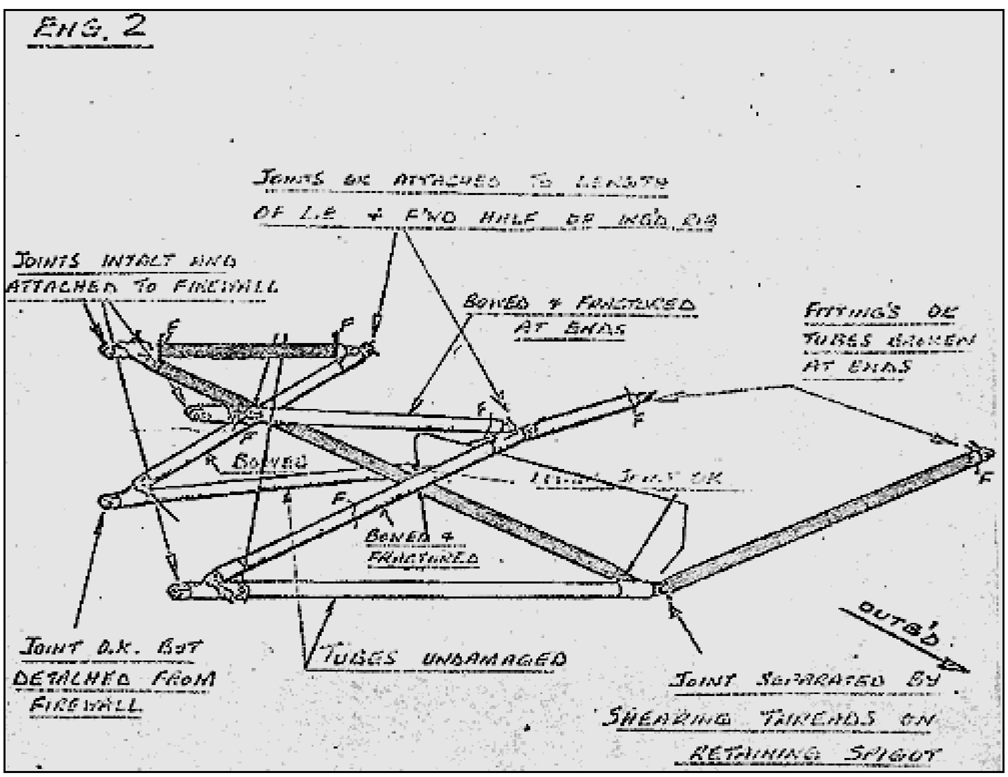


Fig 4.3 - Tubular Structure Inner Nacelles (Items missing are shaded) - F = Fracture

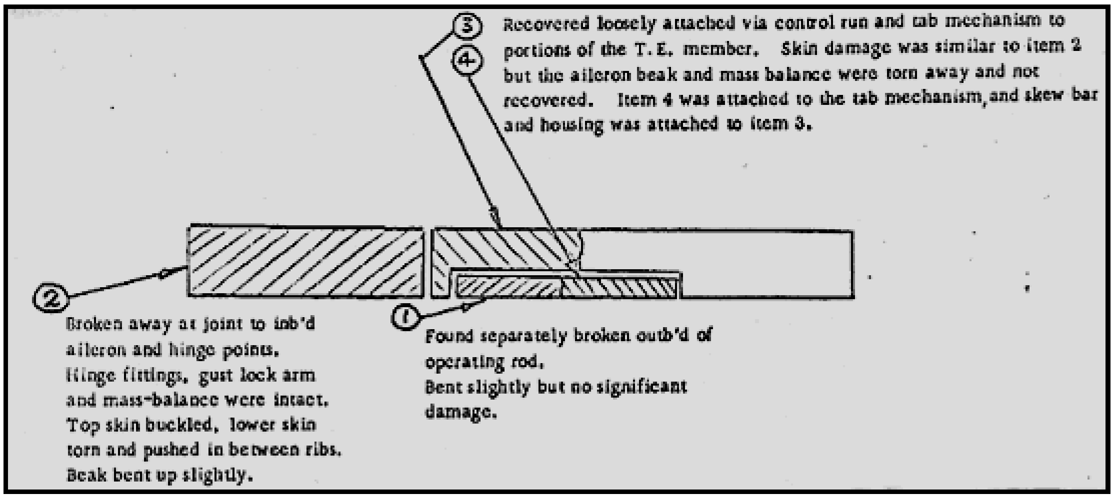




Section 5 Ailerons.

The stb'd aileron and supporting structure had broken away and were not recovered, but the control mechanism local to the ailerons was attached to a portion of the wing trailing-edge member. The skew bar and housing had pulled away from the aileron.

The items recovered on the port side and the damage are illustrated below.



The aileron and supporting structure had broken from the wing. The hinge fittings were attached to the outer aileron but the structure forward of this was missing. Items 3 and 4 which did not include any hinges or supporting structure were recovered loosely attached via the control run and tab mechanism to inb'd portions of the trailing edge member.

Summary of Conclusions.

The stb'd aileron and supporting structure was missing but the control mechanism local to the aileron was recovered and the skew bar and housing had pulled away from the aileron.

The nature of the damage on the items recovered on the port side indicates that they were attached at impact and no evidence was uncovered to suggest that any defect was present in the ailerons or control run prior to impact. (see also section entitled flying control runs).

Section 6 – Undercarriage and Mounting Structure.

The three units were recovered with the exception of the wheels, brake assembly and the inner cylinder belonging to the stb'd main unit. The nose unit had broken away and was located in two pieces. The port and stb'd main units were attached to the surrounding wing structure but the wheels, brakes and inner cylinder had broken away from both. The port assembly was found early on floating with the tyres still inflated.

Nose undercarriage. The inner cylinder and wheels had broken clear of the outer cylinder. The gland nut was split. The ram foot fitting was fractured and the forward portion of it, the door retraction ring and the torque link below the fracture were missing. Wheel hubs were badly corroded and the tyres had small cuts in a few places. The remainder of the undercarriage was located fixed to part of the mounting structure.

The triangulated structure supporting the main pivot was ripped away from the bulkhead but still attached to the main pivot, the lower stb'd side member and bracing tube were missing but a portion of the port tube was attached close to the pivot. The retraction jack was extended (i.e. undercarriage retracted) and bent, it was attached to the locking unit and right had portion of the forward pick up beam. The left half of the beam was recovered separately. The dampers were bent and damaged. The downlock receiver and cross beam with some of the side supporting structure was recovered separately, but the uplock receiver and surrounding structure had been torn out of the bulkhead and was missing.

The only items of the doors and operating mechanism recovered were the operating beam with some rods attached and a small portion of the port door.

The direction of failure of the beam picking up the fw'd end of the jack, the bowing of the jack and dampers and the tear out of the supporting structure from the bulkhead are all indicative of high fw'd inertia loads at impact. The bulkhead at stn. 32 was badly fragmented caused by the ripping out of the uplock and undercarriage support structure. The distortion and damage was consistent with high water forces being applied to the bulkhead in an aft direction and reacted by fw'd inertia loads from the undercarriage. Most of the catenary floor above the wheels was missing and although no direct evidence was available it is likely that the undercarriage was forced hard-up, this contributing to failure of the torque links and ram foot fitting.

Main undercarriage units. The damage to the main undercarriage units and the surrounding structure is illustrated in Fig. 6.1 and 6.2. The backstay fracture, spar boom impact mark, and bending of the jack are common to both main units. It is reasoned that these were caused by up impact loads applied to the wheels which in turn induced forces as shown by the arrows in Fig. 6.1 and 6.2.

On the port undercarriage the fitting at the trailing edge was bent forward and the bracing tubes failed in compression, both probably caused by forward inertia loads on the undercarriage. Also downward inertia loads might explain the bending of the door operating hook.

The bracing tubes on the stb'd side failed in tension. This suggests the absence of any appreciable f'wd load, the tension failures being caused by a combination of aft and upward impact loads.

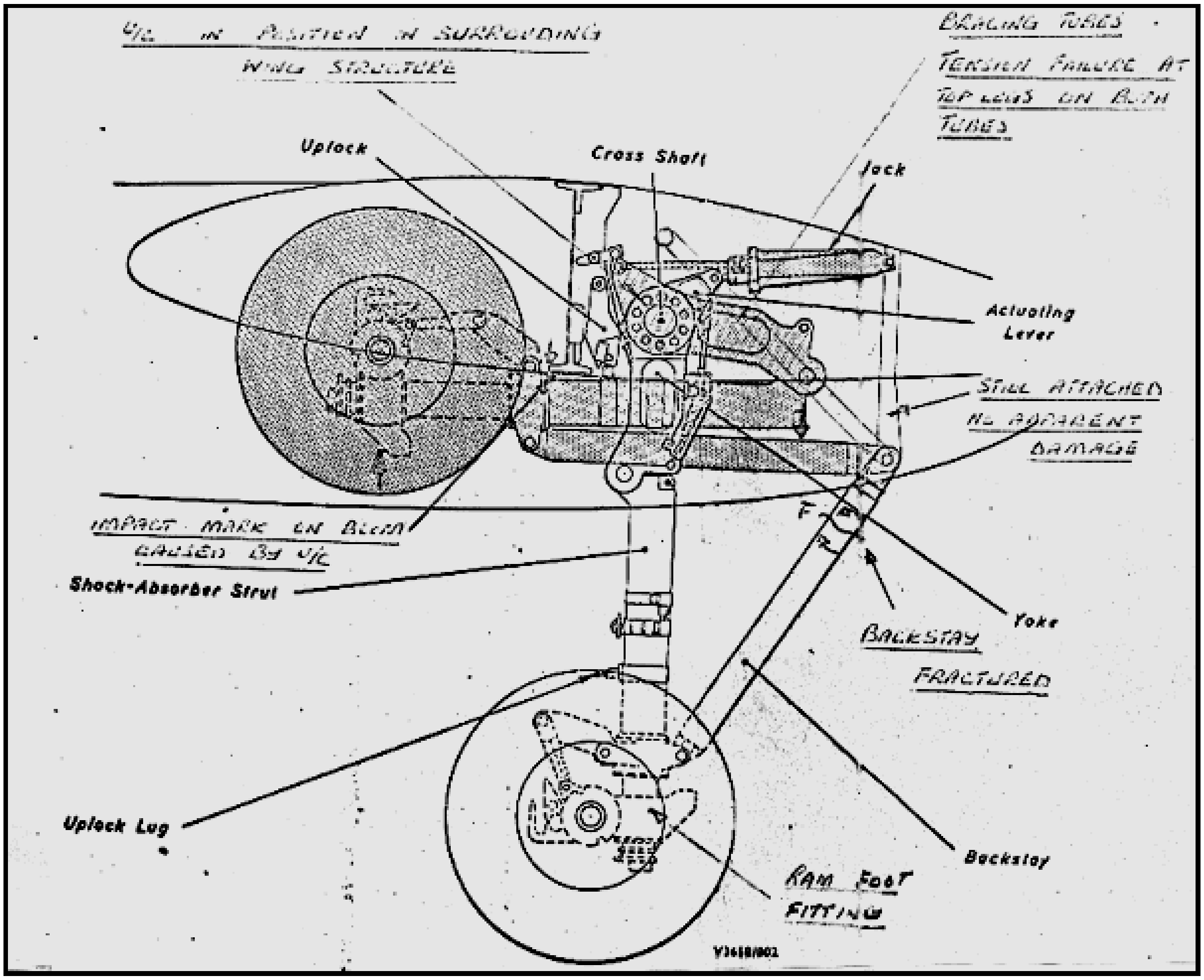
Summary of Conclusions. It has been established from the hydraulic system and verified by examination of the undercarriage that all three units were retracted at impact, and the damage was readily explained as having been caused by impact.

The damage to both main units is consistent with:

1. The aircraft descending rapidly, with only moderate forward speed and impacting at a shallow angle.

2. The stb'd wing being slightly low at initial impact thus inducing forward and down inertia loads onto the port unit before the application of high up impact loads.

<u>Stb'd Main Unit Fig. 6.1.</u>



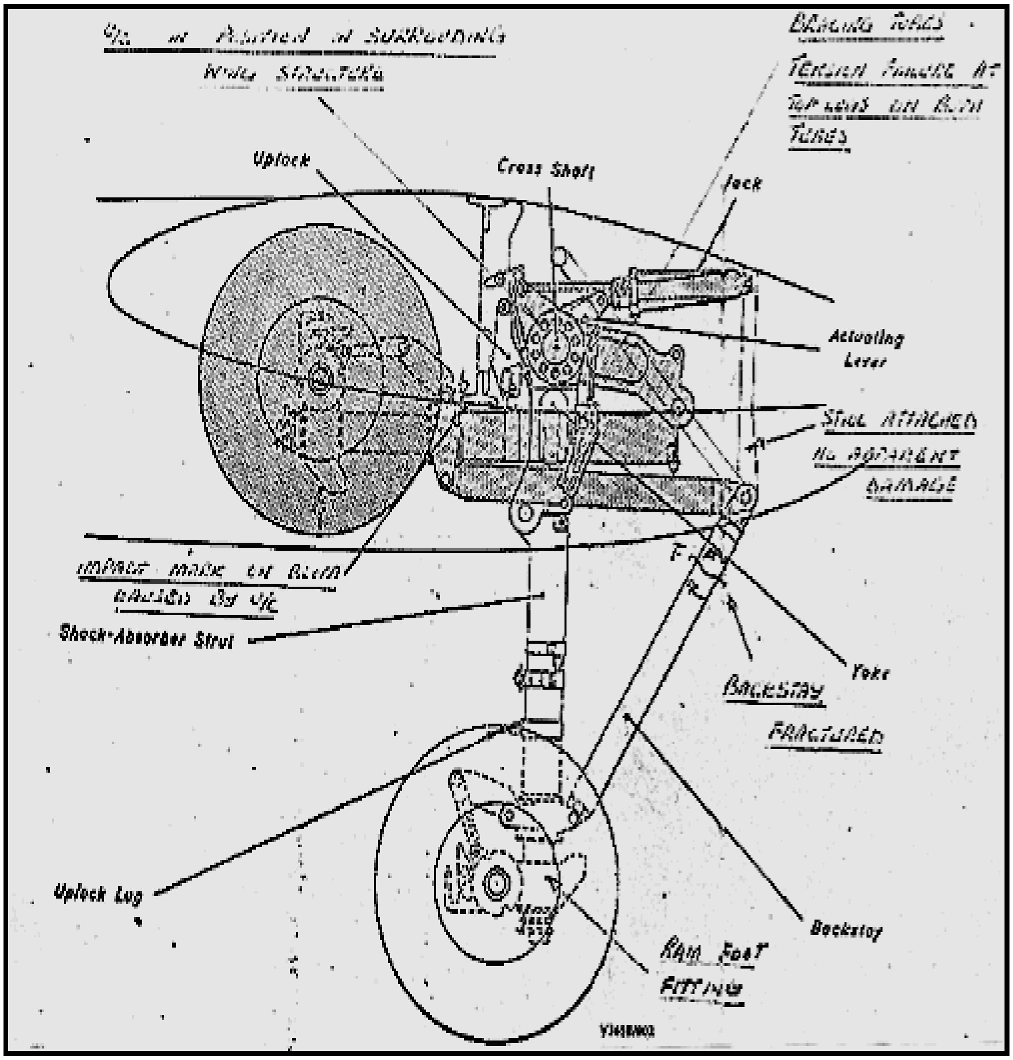
The unit was recovered attached to the wing structure with the jack, dampers, locks and supporting structure accounted for, but the inner cylinder, wheels, brakes, gland nut, doors and operating mechanism had been ripped away and were not recovered.

The torque links were attached to the outer cylinder and had broken away from the ram foot fitting at the lower joint.

The downlock plungers were withdrawn, the jack was extended (i.e. undercarriage up) bent but attached at both sides. The uplock was in position, the jaws were open and the lug on the undercarriage was undamaged.

The remaining damage is illustrated in Fig. 6.1.

Port Main Unit Fig. 6.2.



The unit was recovered attached to the surrounding wing structure with the jack, dampers, locks and supporting structure accounted for. The inner cylinder, wheels and brakes had broken away and were found floating with the wheels inflated. The doors and mechanism had ripped clear and only the operating beam was recovered.

The torque links were attached to the outer cylinder and broken away at the ram foot fitting joint. The fitting was cracked, the gland nut was missing and the door operating hook was bent out.

The downlock plungers were withdrawn, the jack was extended (i.e. undercarriage up) slightly bent but attached at both ends. The uplock was damaged and the jaws were closed. The lug on the undercarriage had been bent up and pulled out.

The remaining damage is illustrated in Fig. 6.2.

<u>Section 7 Fuselage</u>

Contents

Section 7 Fuselage

Section 7.1. Fuselage Pressure Shell.

Introduction

The fuselage pressure shell was severely fragmented and about 15% of it was recovered. The location and approximate size of the identified pieces are shown diagrammatically in Fig. 7.2. About 140 small pieces of skin stringers and frames were identified as from the pressure shell but were not placed.

Most of the catenary floor beams in the nose bay area were recovered and it was possible to piece together the pressure bulkhead at stn. 132. The pressure floor was attached between stn. 112 and 132, but forward of this only small pieces were located fixed to the beams. The forward entrance door, port rear door and fragments of the front door in the cargo hold were recovered.

Generally all pieces were badly distorted with stringers, frames and any local reinforcing structure still attached. The largest and least damaged pieces were located at the rear doors.

Doors. There are six pressure sealed doors. Two on the port side and four on the stb'd side. Refer to Fig. 7.2.

The seals from the front and rear entry doors on the port side were recovered and the pressure bottle from the nose-bay complete with gauge, charging point, filter, valves and local piping. Gauge reading 480 p.s.i. The max normal is 300 and min. 50. Also recovered was the emergency pressure valve fitted at floor level by the front entrance door. The lever was in the emergency position, i.e. open to cabin. The high gauge reading and the position of the lever on the emergency pressure valve were almost certainly caused by impact loads and no significance is attached to them.

Forward Entrance Door. (port side) This door and part of the surround structure were recovered and it was possible to establish that the door was intact and securely locked at impact.

The bottom of the door was badly damaged and the front lower corner was missing. The distortion of the lower surround structure was similar to that of the door and it was apparent that the main impact loads were supplied via the lower surround structure in an upward and aft direction. The overall pattern of distortion suggests that the door separated by peeling outwards and upwards starting from the bottom forward end. Most of the door operating mechanism was intact the top and bottom front latch pins were missing but the remaining four were attached and in the door closed position. The external handle was attached and closed, but the internal handle was missing.

Rear Entrance Door (Port Side) The door and upper portion of the surround structure were recovered and again it was possible to establish from the damage that the door was intact and securely locked at impact. The impact loads were predominantly up, supplied via the lower surround structure. The bottom of the door was folded up and out, finally separating from the fuselage by peeling outwards, starting from the bottom.

Front Cargo Hold Door (Stb'd Side) The lower half of the surround structure and two small pieces of the door including the handle were recovered. The severe fragmentation of the door could only take place if it was in position and securely locked at impact.

Rear Cargo Hold Door (Stb'd Side) Some of the surrounding structure was recovered but nothing of the door, and it is impossible to say if the door was in position at impact.

Rear Entrance Door (Stb'd Side) This door is similar and opposite to the rear entrance door on the port side. The surround structure at the top, bottom and forward sides of the door was recovered. The break up pattern of this suggests that the latch pins were engaged, also the outside skin on the forward side near the top had been forced out slightly, most likely by the door edge at impact. The indications thus are that the door was intact and closed at impact.

Rear Freight Door (Stb'd Side) Nothing of the door or surround was recovered. The rear freight hold was empty and is not normally accessible from the cabin.

Windows Items recovered: 3 pieces of perspex from the window panels, seals from the third and fifth window port side, the window surround structure illustrated in Fig. 7.2. and a few other pieces of surround structure not related to any particular window. No evidence was found of any defect or failure having been present before the crash.

Frames Items recovered: Most of the main spar frame and trailing edge member pick-up frame, lower portions of the leading edge frame, a portion of frame 132 above the pressure bulkhead on the port side, about sixteen unplaced short lengths of typical light frame, and the segments of frame which are still generally attached to the recovered skin items shown in Fig. 7.2. Altogether this makes up at 15% of the total frame structure.

The double main frame was attached to the spar, but the upper portion between the top frame joints was missing. The skin had torn away completely leaving the shear cleats attached to the frame. The portions protruding below the spar, and the webs of the spar were badly damaged by impact loads applied in an aft direction. The frame picking up the wing trailing edge member was broken in numerous places and a portion of the lower starboard side was missing. Again the skin had torn completely away leaving the shear cleats attached. The fractures close to the floor beam intersection and the overall distortion suggests the application of impact loads in an aft and up direction applied to the bottom of the fuselage and reacted to some extent by forward inertia loads at floor level.

A detailed examination of the items revealed nothing that could have been caused by forces other than impact, and confirmed the evidence from doors, i.e. upward and aft impact loads were applied to the bottom of the fuselage.

Skin Stringers and Local Reinforcing The location and approximate size of the placed items are shown in Fig. 7.2. As far as could be assessed none of the unplaced items came from the rear pressure bulkhead area, and it is therefore considered that further identification (which would be difficult if not impossible in a number of cases) would not alter the general impression, i.e. pieces recovered at random along the length of the fuselage from the nose to stn. 800 indicating that fragmentation had taken place over this length. Some wing structure was attached to the items in the region of the wing/fuselage intersection. The L.E. frame joints and short lengths of the frame were attached to the forward pieces and the electrical looms and pressure box were still fixed to the large portion on the starboard side. All were severely distorted by up and aft impact loads. Another item warranting separate comment here is the structure over the rear doors. This had a distinct crease line on the port side at an angle of 60º to the centre line measured from the rear and all of the stringers were fractured along this line. This crease was probably caused by empennage loads at impact.

The structure recovered was examined in detail and it was noted that in general the stringers, frames and local reinforcing were still attached to the skin. No evidence or any signs of important pre-crash corrosion, fire, explosion or any signs of in-flight failure due to pressure, shear or bending loads.

Catenary Floor and Bulkhead at Stn. 132 Recovered were: Most of the bulkhead at stn. 132, the support beams forward of 132 with the exception of 72, the catenary floor between 112 and 132 loosely in position and small fragments of the remainder of the caterary floor attached to the recovered beams. The majority of the beams had broken away adjacent to the fuselage side and the lighter forward beams were bowed up and twisted (lower boom aft and up). The damage was almost symmetrical about the centre line. The catenary floor between 112 and 132 was loosely attached to the adjacent beams but was badly damaged particularly on the stb'd side in the region of the jump seat. Forward to stn. 112 and below the crew floors the catenary floor had broken away from the beams and was not recovered. The most severe damage occurred in the region of the crew seats and nose wheels.

The bulkhead at stn. 132 supporting the nose undercarriage and taking pressure loads as badly damaged and portions had broken away with the nose undercarriage support structure. The break-up pattern could be explained by aft impact loads and associated forward undercarriage inertia loads. The uplock receiver and the surrounding area of the bulkhead were missing.

Examination of the structure did not reveal any signs of pre-crash defect or failure.

7.2 Cabin Floor and Associated Structure

Cabin Floor The portions of the cabin floor are shown in Fig. 7.1. The unplaced portions consisted of sixteen small pieces of the side panels and one small piece of the centre panel.

About one-third of the floor was recovered, and the pieces were distributed throughout the length of the cabin. The centre panels have an end grain Balsa core and were recovered floating. The side panels are of conventional construction. In the region of stn. 323 bits of the floor beams were loosely attached to the side panels, elsewhere they had broken completely away.

Compression folding under forward loads was apparent particularly on the front panels. There was also a general downward dishing of the panels in the central area of the fuselage and the access panel adjacent to stn. 485 had been forced down and impacted hard onto the rear face of the main spar.

The cabin floor could have had a bearing on the accident to the extent that a sudden de-pressurisation could cause deformation and fouling of the control runs. This hypothesis was investigated, most of the control runs and floor were missing and although some downwards dishing of the aisle panels in the control area of the fuselage had taken place there was no evidence to suggest that this was caused other than by downward inertia forces or by inflow of water at impact.

Floor Beams Recovered were: Pieces from most of the floor beams forward of the main spar, most of 501, short lengths of 523 and 606 and thirteen other unplaced bits of beam and support structure. The beams were badly damaged and generally broken at inner seat rails and close to the fuselage side. Beam 198 was virtually complete and symmetrically kinked at both inner seat rails by forward loads applied by the rails. On some of the forward beams bits and pieces of the control runs and supporting members were attached.

The damage was readily attributable to impact forces.

Seat Rails About 15% of the seat rails were recovered in short lengths and some pieces were still attached to the floor structure forward of the spar. Immersion in the sea had caused severe corrosion and it was noted that in some cases the seats had separated from the rails by shearing the edges of the retainers.

7.3 Cockpit Area

Introduction Recovered were the pilots and co-pilots floor with the seat mounting structure, the back frame of the pilots seat with shoulder harness attached, portion of the co-pilots shoulder harness, the jump seat, empty radio rack frame from the stb'd side, cockpit entry door and the aft face and core of the bulkhead at the rear of the cockpit on the stb'd side. The control runs were in position under the pilots floor.

Floors Seats and Harness The pilots floor was virtually complete and damage consisted mainly of compression folds in a fore and aft direction associated with bending and tearing. The pilots right shoe was recovered trapped in a compression fold just clear of the right rudder pedal. The co-pilots floor was more severely damaged and the area just forward of the seat was missing.

The seat retaining bolts were torn out of the mounting channels and only the back frame of the Captains seat was recovered. The shoulder harness was attached complete and secured to the lock-on harness/release mechanism and inertia reel. The strap was pulled out of the reel to the full extent. The lap straps were missing but one of the fittings was attached to the lock-on harness/release mechanism and the other had been torn out. Only the straps of the co-pilots shoulder harness below the Y joint were recovered. There were signs of over straining on one of the straps at the end fitting and the pick-up lugs on both fittings were bent. The evidence clearly indicates that both flight crew were using the shoulder harness at impact and that the Captain's lap strap was fastened. Most probably the co-pilot's lap strap was also fastened. The jump seat had the back and lap strap attached. It was unoccupied and appeared to have broken clear and collapsed mainly under up loads.

Bulkhead at the Rear of the Cockpit on the Stb'd Side.

The fore and aft face of this bulkhead were located soon after commencement of recovery operations and it was pieced together. A portion was cut away to study a stain which subsequently proved to be blood. At a later stage interest was directed to a cluster of small circular holes in the upper right side, some of which were filled with a plastic metallic substance. However a detailed investigation revealed that holes were caused by repeated screwing and unscrewing of the hat-rack to the bulkhead which is removed during major checks and may or may not go back in exactly the same place on some aircraft. Also plastic type filler is used by the Aer Lingus furnishing shops to plug redundant holes.

Other Items The curved frame of the stb'd radio rack was badly damaged at the bottom forward corner by impact loads, and examination of the remaining items revealed nothing not due to impact.

7.4 Items from Cabin Interior

Introduction The configuration in use is illustrated in Fig. 7.1. Seats, bulkhead, toilets, galleys, carpets and other fixtures and furnishings in the main cabin were torn loose and shattered by impact forces. The bits and pieces recovered were divorced completely from the fuselage and they are noted and discussed below.

Hostess Seats

Aft Seat The seat base was recovered with the lap strap fitting missing and examination of the seat fittings showed that the stb'd lap strap had become detached from the retaining bolt, but, on the port side the retaining bolt was missing. Damage to both the seat base and frame was slight.

Double Seat at Main Entrance Door The items recovered were: the back padding, the seat base with lap strap fittings, pieces of the fixing brackets and one sliding tube attached, and the port sliding tube which had broken away. The support frame and the lap straps which had become detached from the retaining rings were missing. The back padding was in good condition, the seat covering was ripped and the seat pans were distorted probably by blows received during break-up, but the tubular frame supporting the seat was undamaged.

As noted damage to both seats was superficial. This is particularly true of the aft seat which is f'wd facing and had the support frame still attached. There were no signs of overstraining at the lap strap fittings and loads from the seat belts would not normally cause failure of the strap hook or indeed of the missing bolt. The evidence is conflicting but a possible explanation is that the straps sprung free during break-up. A few lap straps found separately but not necessarily from the hostesses seats had separated in this manner. As regards the missing bolt, it should be noted that the aft seat was not recovered until 18 months after the accident and there is the possibility that corrosion could weaken the missing nut/bolt sufficiently to permit it to fall away during recovery.

The above evidence although not entirely conclusive indicates that the seats provided for the hostesses were not being used. However, although the full complement of passengers were aboard, two were infants, and this could leave two passenger seats vacant in an emergency.

<u>Life Vests, Seat Belts and Seats</u>

Two life vests were recovered. These were still in their covers and unused.

The seat belt items recovered consisted of: One belt complete and fastened. Attached to a portion of frame on one side and broken away at the small fixing pin on the other.

Three lap straps, two short and one long. The long one was fixed to a portion of seat and the attachment fitting was twisted. The short straps were unlocked from the seats. Examination revealed no clear evidence of overstressing and it was not possible to determine if in fact they were fastened at impact.

Damage was severe on the passenger seats and the various components recovered are listed:-

One gold covered seat back with folding table
Six arm rests with bits of support tube attached
Remnants of 9 seat back tables
Two triple seat support frames
Two double seat support frames
Three other pieces of side frame tubing.

The seat back had broken away at the bottom attachment and there was some overall distortion and signs of impact on the aft side. The steel side frames had broken clear at the attachment to the seat base and away from the seat rails. In a number of cases the frames had parted from the seat rail by shearing the edges of the retainers. All were badly buckled by forward and down loads with the exception of one triple seat frame. Three of the arm rests had been forced hard down at the front but only slight distortion was apparent on the other three.

Very high down inertia loads would be experienced at impact as well as f'wd loads and if occupants were strapped in, these loads would distort the seat frames. One of the triple seat frames although broken away was not distorted, implying that the occupants supported by the frame were not strapped in. The evidence however, both from the seats and lap straps is inconclusive and doubt must remain.

Seat Cushions and Pillows

Recovered:

6 seat cushions with green covers	)	Total:
1 seat cushion with gold cover	)	
10 seat cushions without covers	)	17 cushions
1 green cover	)	7 green covers
3 gold covers	)	4 gold covers
2 small pillows without covers		
1 large pillow with green cover		

Some fuel contamination was apparent and a few were cut and holed otherwise damage was slight. To investigate the possibility of any fragments from an explosive device being imbedded in the foam it was decided to X-ray all of the items. The results were negative.

The green and gold covers are distributed in a random manner and no particular significance can be attributed to the relative numbers of green and gold covers found.

Carpets Seven strips of carpet were recovered, varying in length from 2 ½' to 11 ½ '. Apart from some tears the condition was generally good and no unaccountable damage was noted.

Other items

The remaining items from the passenger cabin recovered included: Overhead water tank (mounted on the roof between toilets) two water heaters from toilet washbasins, one with control unit attached, service panel, polythene piping connecting the foregoing items, toilet container, toilet seat, hot water container from the galley and cabin fire extinguisher.

Forty feet of the centre aisle roof panel with lights, P.A. speakers and electrical wiring attached, also buffet control panel at the rear port side of the fuselage.

Escape chute cover and odd bits and pieces of internal bulkhead and secondary support structure, three window blinds and surround panels, sound proofing, hat-rack edge member and cold air ducting.

The items were dislodged from their mountings and the damage in general was typical of that caused by impact. One of the window blinds was badly discoloured on the inside.

7.5. Personal Belongings A small amount of personal luggage was recovered. The few rigid items were broken and crushed, otherwise the only damage was that caused by immersion in the sea.

7.6. Summary of Conclusions

1. The impact, associated inertia forces and the subsequent ingress of water under pressure caused complete disruption of the structure and cabin interior. The nature of the damage suggests that the aircraft struck the water right way up and at a shallow angle with a high velocity of descent and moderate forward speed.

2. The fragmentation pattern shown in fig. 2 implies that the fuselage structure from the nose to stn. 800 was at least capable of supporting the flight loads imposed up to impact.

3. There is positive evidence that three of the doors were intact and closed at impact. There is some doubt about the Stb'd rear entry door and no evidence is available on the rear cargo hold door and the rear freight door both on the stb'd side.

4. No evidence was found to suggest fire, detonation of an explosive device, or bits of the fuselage skin having been shed in flight causing depressurisation and striking or jamming controls. The possibility of any of these having occurred however cannot be completely eliminated in view of the small amount of fuselage wreckage recovered. (See also note below).

5. The flight crew were strapped in and using the inertia reel shoulder harness at impact. It was not possible to establish from the wreckage if in fact the cabin staff and passengers were or were not all strapped in at impact.

Note

Extensive corrosion checks were carried out by (Scottish Aviation Limited) and the aircraft was released during February, 1967. Two of the rear belly panels were replaced and other areas of light corrosion were cleaned out and reprotected and repaired where necessary. It should also be noted that the corrosion normally found takes the form of localised deep pockets generally visible externally before the structural integrity of the pressure shell is seriously impaired. The lower pressure differential in use on the aircraft (4 ½ p.s.i. design max 6 ½ p.s.i.) further reduces the risk of having a serious failure.

Attached Diagrams

- Fig 7.1 - Diagram 1
  Fig 7.1 - Diagrams 2,3 & 4
- Fig 7.2

Fig 7.1 - Diagram 1

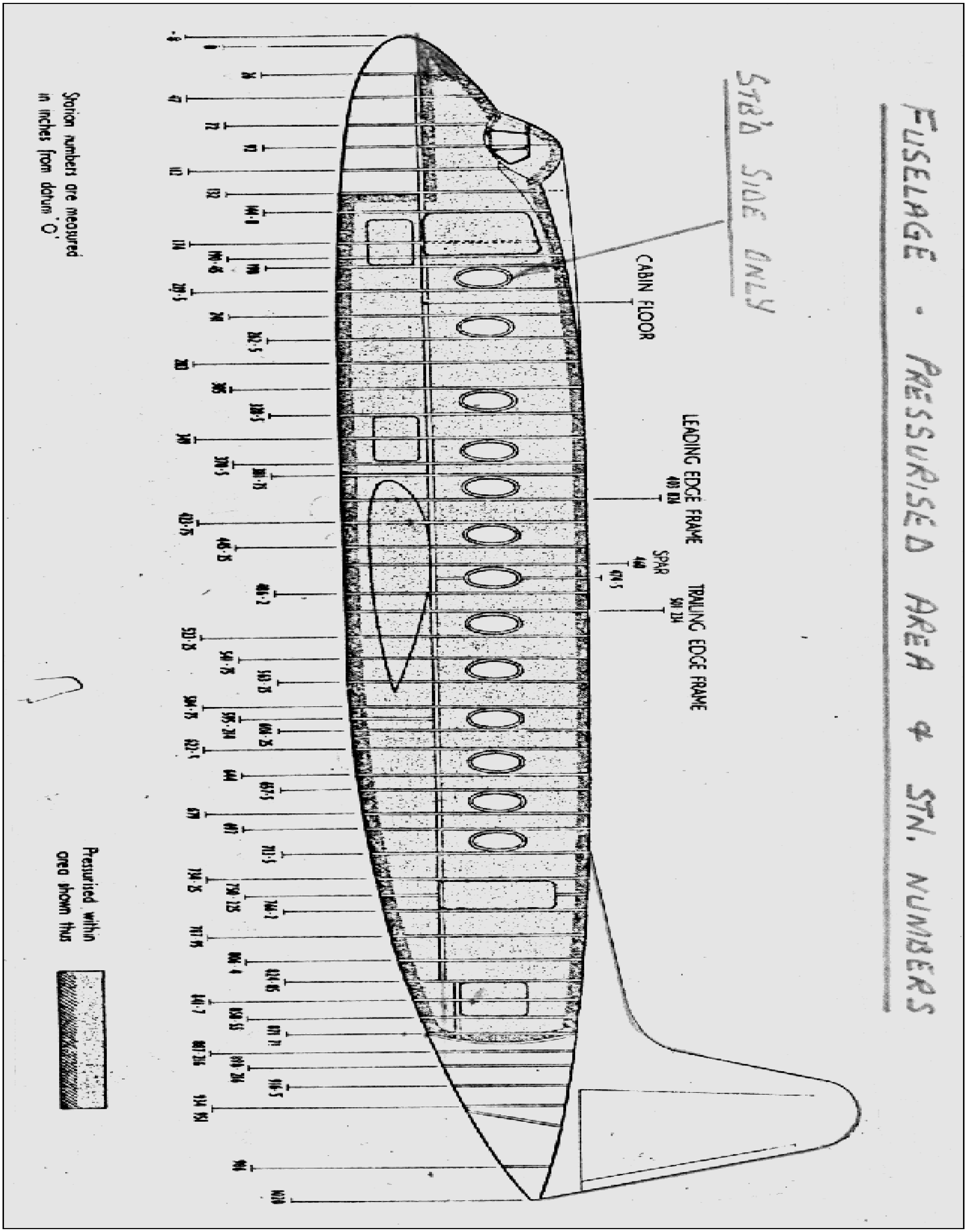
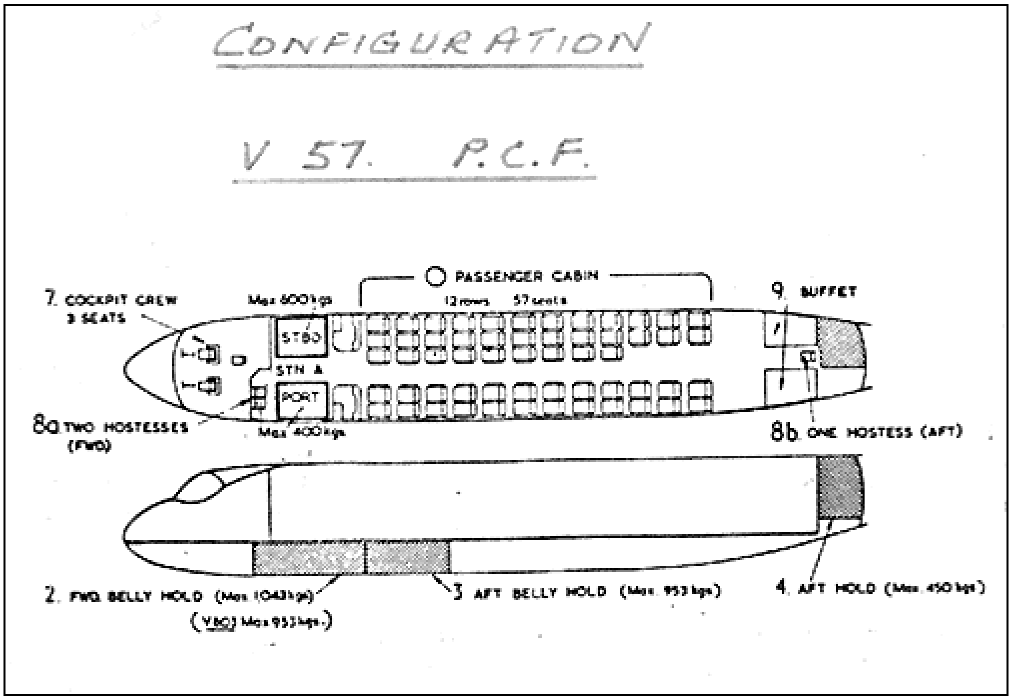


Fig 7.1 - Diagrams 2, 3 & 4



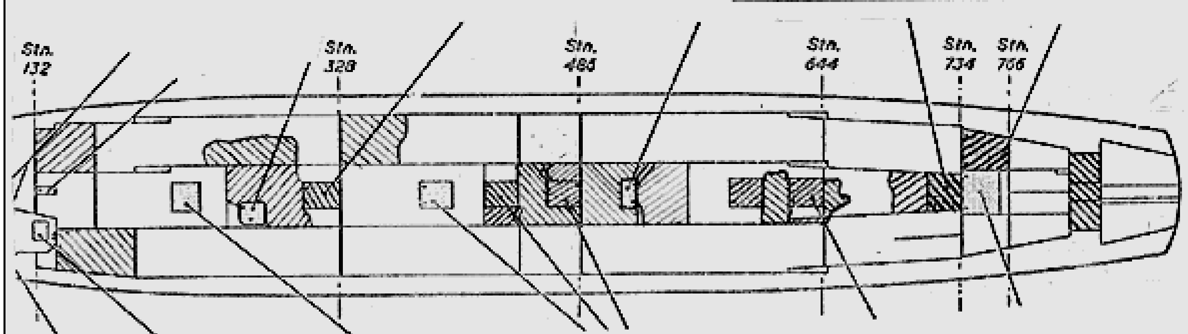


FIG 7·1

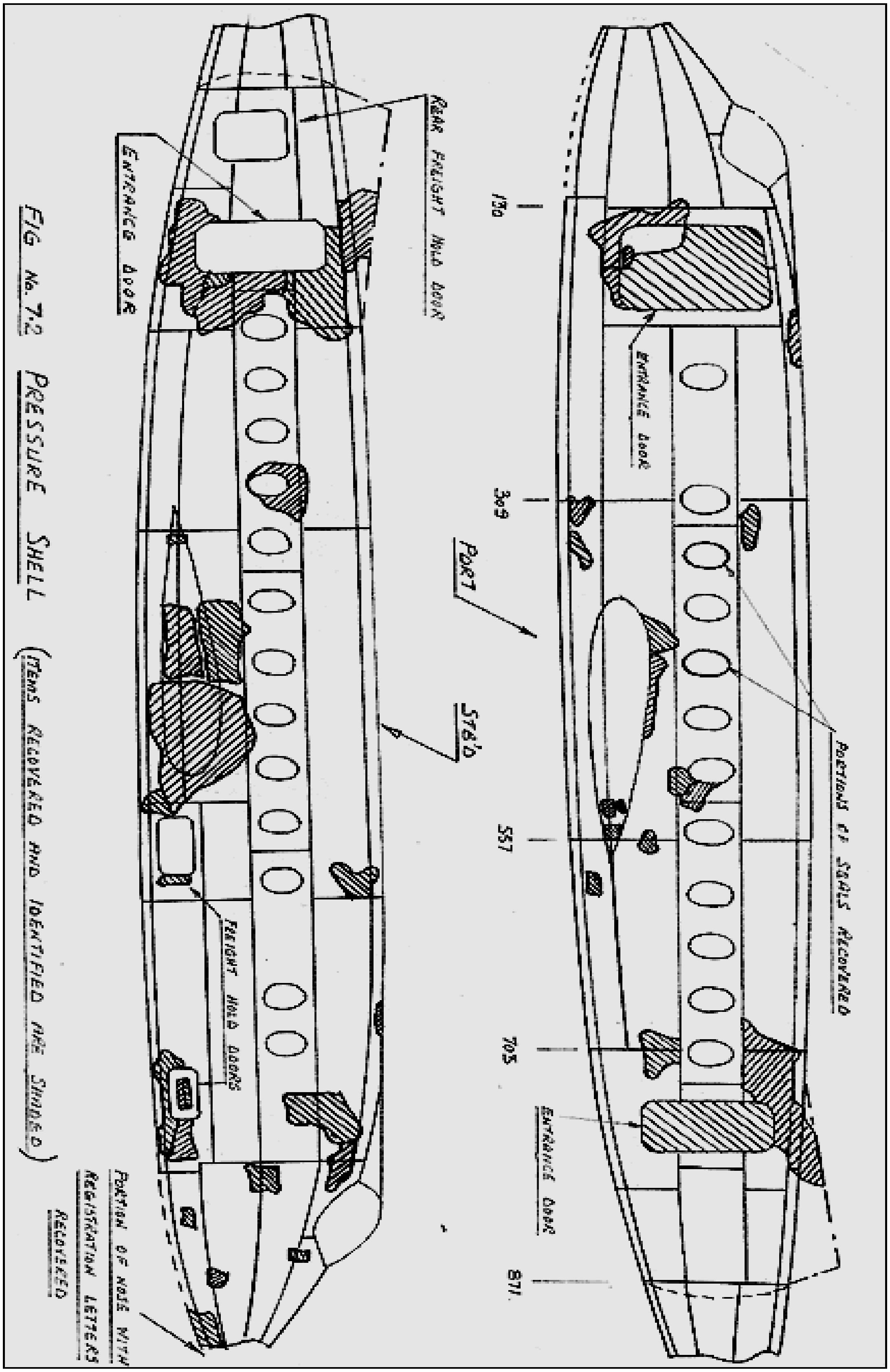
CREW: CAPTAIN CO-PILOT AND TWO HOSTESSES.

PASSENGERS. 35 M. 20 F 2 I
TOTAL 57

BAGGAGE 636 KG. FWD. HOLD
264 KG. AFT. HOLD

FREIGHT. NIL.

Fig 7.2 Pressure Shell (Items recovered and identified are shaded)



Section 8 Fin and Rudder

Recovered were:- The upper two-thirds of the fin and rudder structure complete, about 3 sq. feet of skin from the lower stb'd side of the rudder, the trim and rudder servo tab above the upper skew bar attachment, the rudder torque tube with a portion of the rudder and rib attached, some of the dorsal extension attached to the fuselage skin and the removable panel at the top of the dorsal extension.

The rudder torque tube is dealt with as part of the flying control runs and the pertinent damage to the rudder and fin structure is illustrated on Fig. 8.1.

The upper two-thirds of the fin and rudder was complete and recovered in one piece. The rudder was attached at the three hinge points and the trim and servo tab controls were intact above the fracture. The nature of the failure and the general skin panting and buckling particularly noticeable towards the lower end was undoubtedly caused by high down inertia forces at impact.

The rudder had been forced forward and it was distorted above both upper hinge points by inertia loads forcing it down onto the hinge arms. The mass balance weight on the L.E. of the rudder was also forced down and had pierced the top two diaphragms on the fin extension below the second hinge. Subsequent to this the rudder had been twisted, and the displaced mass balance was clear of the stb'd side of the fin. The stb'd side of the fin extension between hinges 2 and 3 was dished inwards and a hole had been punched in the rudder skin on the stb'd side below and aft of the second hinge. The top of the rudder was damaged by what appeared to be two separate blows, one coming from the top and slightly inclined to the stb'd side and the other close to the tab hinge sigot and from the back, the latter blow displacing the hinge spigot. The navigation light on top of the fin was missing, the surrounding structure was damaged, and the hot air de-icing vent covers on the fin were corroded almost completely away.

The upper portion of the tab was recovered separately, it had parted from the upper hinge spigot and was broken above the skew bar. The port side of the tab was creased along its length as shown in Fig. 8.1. A short length of tab was still attached to the skew bar and the fractured surfaces on this were severely mangled.

Summary of Conclusions

Insufficient structure was recovered to enable a thorough break-up analysis to be carried out and it is impossible to say what direction the structure was thrown after break-up or indeed what other pieces of wreckage it may have come in contact with. For this reason the damage at the top of the rudder, the dishing and hoeing on the stb'd fin skin, and the tab creasing is not readily explainable but there are clearly no indications that it is other than impact damage.

The rest of the damage is indicative of the fin, rudder, and tab being on the aircraft at impact and being subjected to impact forces on the bottom and inertia forces increasing in magnitude down the fin and rudder. There were also forward inertia loads present. It would appear that the structure below the fracture collapsed essentially under compression loads and this could twist the rudder torque tube off in the manner described. (see section on flying controls).

In conclusion it is apparent that the fin, rudder and tab were on the aircraft at impact and no evidence was uncovered to suggest the presence of any damage or defect which would prevent normal operation. The location of the piercing of the diaphragms on the fin extension by the mass balance signifies that when the impact forces were applied the rudder was slightly left of centre.

Attached Diagrams

Fig 8.1

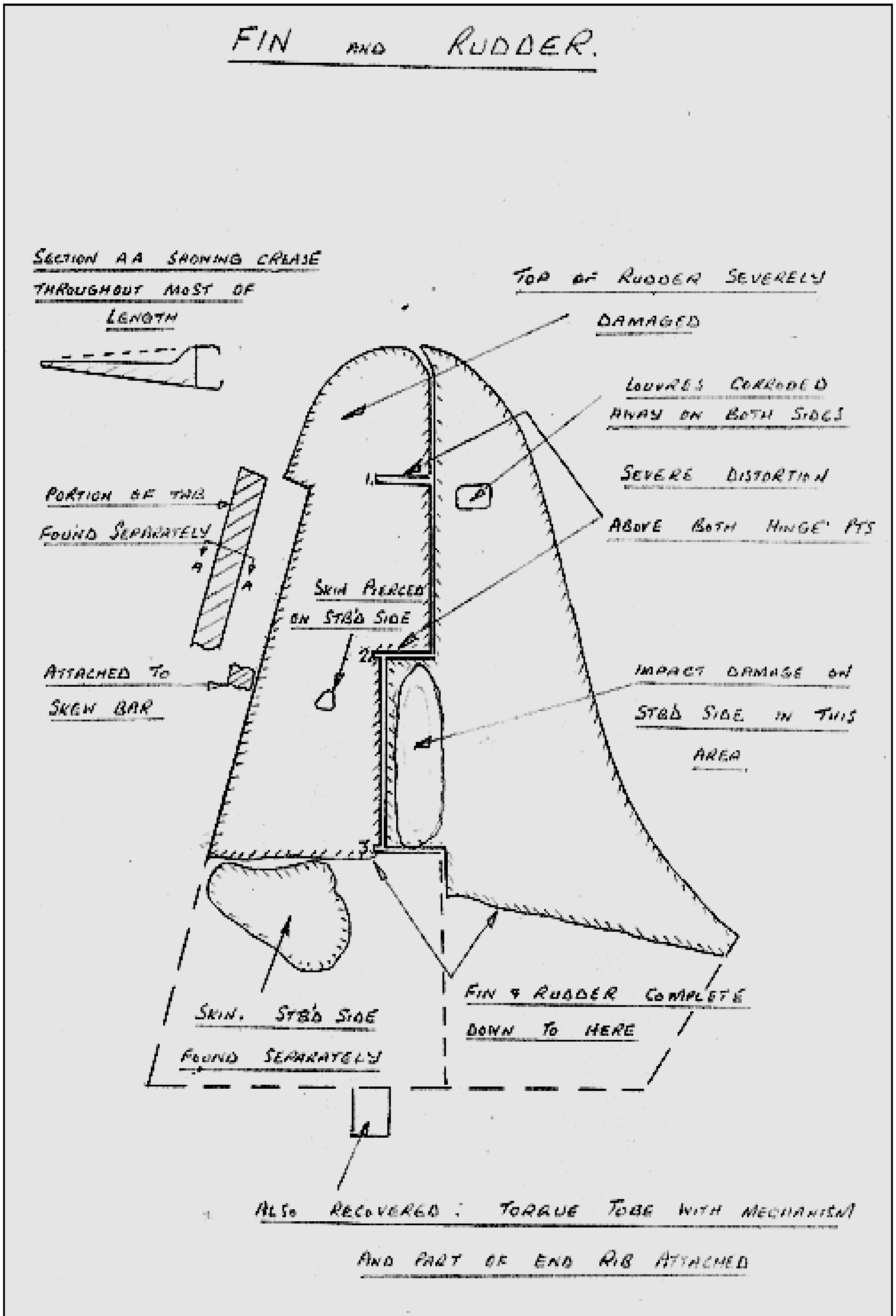


FIG 8·1

Section 9 Tailplane and Elevator

The items recovered were the inner 18" of the elevator spring tab and the outer 39" of the elevator trim tab. The tailplanes, elevators and the fuselage structure in the tailcone area were all missing.

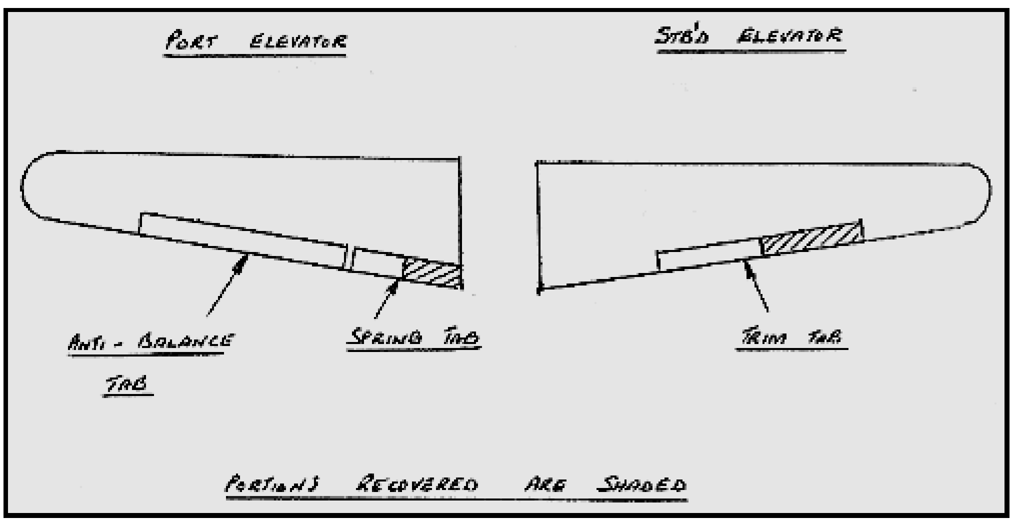
The portion of the trim tab was recovered in the main wreckage area but the portion of spring tab was washed up on the beach between Greenore Pt. And Rosslare Harbour.

Both tabs had fractured just clear of the skew bar attachment points and had been pulled clear of the end hinge spigots. The position of the fractures on both tabs is where failure may be expected under impact loads, i.e. fracturing just inb'd and outb'd of the skew bar attachment leaving a small length attached to the skew bar.

Wreckage investigation has shown that the aircraft struck the water at a shallow angle with moderate forward speed and a high velocity of descent. This implies that some longitudinal stablilisation or control was available at impact.

Summary of Conclusions

The evidence available does not eliminate the possibility of a defect or failure in the elevator and/or tailplanes having contributed to the accident. In this respect it is significant that the portion of the spring tab was found on the beach and not in the main wreckage area.



Section 10 Pedestal

The pedestal had been displaced from its mountings and was recovered with other wreckage from the cockpit area. The throttle and H.P. cock rods were broken under the floor and the trim circuits were disconnected at the lower sprockets. The primary damage was caused by impact forces applied to the bottom and forward end. Direction of load application appeared to be up, aft and from the port side.

Rudder Trim The mechanism was mounted in its normal position and little damage was apparent. The trim indicator had broken but a portion of including the figures 3 and 4 on the right side was fixed to the drive spindle. This gave rudder trim close to the neutral position. The chain drive down the pedestal and the tensioner were unbroken but the lower sprocket was forced up out of position.

Elevator Trim Again the mechanism was mounted in its normal position with little apparent damage. The wheel on the port side was loose but the stb'd one was fixed. Corrosion had removed the markings on the stb'd side but by noting the position of the zero mark a trim setting of 2 ½ units nose down was established. The chain drive in the pedestal was unbroken and attached to the lower sprocket which had been forced out of position, the tensioner had broken away from its mountings. The trim motor, drive shaft, clutch and annulus gear were attached.

Aileron Trim The indicator in the pedestal is electrically operated and was firmly in position with the wires attached, but no useful information was obtained from it.

Flaps The selector switches were positioned as follows;-

Main flap selector in the flaps up position
Main motor trip and reset switch in the neutral position
Emergency engage switch locked in the normal position
Emergency selector switch in the centre (off) position.

Undercarriage The undercarriage operating lever was in the down position. It was concluded that it had moved to this position on impact since the actuator and control valve in the hydraulic cupboard were both in the undercarriage up position.

Control Locks The control lock lever was in the off and stowed position and the top of the lever was missing. The mounting was distorted but the chain drive was in position through the pedestal and attached to the rod under the cockpit floor.

Throttles and H.P. Cocks The throttle lever group was seized in position and levers 1, 2 and 4 were bent to the right and lever 3 slightly to the left. The position of the levers varied from ¾ " to 1 ¾ " from the open position.

The H.P. cock levers were damaged and seized in position. The quadrants were broken and the position of the levers varied from almost fully closed to open.

The engine control rods and lever groups down the pedestal and below the floor were displaced and broken by upward impact forces.

Auto-Pilot The control panel was removed for investigation and the results are presented in the auto-pilot report.

The pedestal was sent to the B.A.C. laboratories at Weybridge for a detailed strip examination. No useful additional information was obtained and it was concluded that the damage sustained was caused entirely by impact forces.

Summary of conclusions No evidence was uncovered to suggest the presence of any pre-crash defect or malfunction, and the extensive crash damage sustained must in general render unreliable the engine and flying control settings noted.

Section 11 Flying Control Runs

11.1 Introduction

The fragmentation of the airframe structure at impact caused disintegration of the control runs. Most of the push-pull rods recovered (about 25% of the total) were crushed, broken and trapped by the distortion of the surrounding structure and the magnesium levers were severely corroded by immersion in the sea. The various items recovered from the primary control runs and the trim and control lock system are noted below.

11.2 Controls in the Cockpit

Rudder The rudder bar assemblies were attached to the cockpit floor and were complete with the exception of: the pilots left hand pedal and foot brake mechanism, interconnecting rod and the magnesium lever at the base (probably corroded). The left arm of the pilots rudder bar was bent forward and down and both arms of the co-pilots rudder bar were bent down. Distortion was more severe on the co-pilots side. The pilots right shoe was retrieved. It was trapped by the heel in a compression fold in the floor aft of the right pedal and the floor was pierced below it.

Elevator A portion of wreckage was recovered comprising a length of cross tube, end bearing, lower part of the right elevator lever and portion of the fuselage skin and static vent. Nothing else was recovered.

Aileron The only portion of the aileron circuit recovered was the cross beam, chain pulley shaft and chains. The cross beam had separated from its mountings and the chains were broken.

11.3 Control runs in the pressurised area of the Fuselage

The rods under the pilots floor back to the lever group at stn. 139 were trapped in position and portions of the forward rods on the elevator and aileron circuit were missing. The rods were flattened, bent and fractured at stn. 112. The lever group shaft and supporting structure at stn. 139 were located but the levers were missing (probably corroded). The aileron servo motor which actuates the circuit at stn. 139 was not recovered.

Short lengths of rod were found attached to the mounting structure on three of the forward fuselage underfloor beams. One was located at stn. 282 but the others could not be identified. A portion of the aileron rod bent over the roller guides was protruding from the back of the main spar.

The other items recovered were one of the aileron control run pressure boxes at the fuselage side with the lever shaft attached, (lever corroded) and six short unidentified portions of control rod making up a total length of about 9 feet.

11.4. Controls aft of the Rear Pressure Bulkhead The items recovered in this area were the rudder torque tube with associated mechanism and the trim and servo tab control run complete above the fin and rudder fracture. A portion of the fuselage mounting bracket was attached to the rudder torque tube. It was twisted and fractured and had impacted the top and bottom edges of the torque tube slot. (One slight mark central on the top edge and two on the lower edge 1½" from each side. The mark on the stb'd side was deeper with signs of double impact). The nature of the damage suggests that the rudder was moving towards the left during break-up and examination of the fin and rudder confirmed this.

A piece of rudder end rib was attached to the top of the torque tube. The control rod was broken at the bearing attachment to the torque tube plates and the plates were bent down.

The rudder servo lever was fractured across the lightening hole adjacent to the torque tube. The distortion of the rudder end rib, the direction of failure of the bracket attaching the torque tube to the fuselage, the downward distortion of the lower plate and the direction of rivet shear at the torque tube joint in the rudder are all indicative of the torque tube having been twisted off in an anti-clockwise direction looking forward.

Insufficient structure was recovered to study the failure mode in the area but the fin and rudder had been severely compressed which apparently led to fragmentation at the lower end and this type of loading could twist the torque tube clear in the manner described.

The tab control rod in the rudder had broken at the screwed joint above the lower torque tube and the mechanism above this fracture was mounted in position in the recovered portion of fin and rudder. The balance weight was intact and a short length of tab was attached to the skew bar. The rudder torque tube was sent to B.A.C. laboratories at Weybridge for examination. When checking the tab-spring pre-tension it was found that an incorrect spring had been fitted and that it was similar to the one fitted to the elevator torque tube which has a lower rate. It was impossible to establish where or when this spring came to be fitted but enquiries indicated that the time lapse since initial misassembly was greater than a year and this would indicate that the consequences are not serious.

A complete investigation to determine what effect this would have on the rudder/tab operation was undertaken by B.A.C. and their findings are summarised below:

1. For all normal flying it is possible that the pilot would not notice the lighter rudder feel. If he did, he would probably class the aircraft as slightly more responsive to rudder than most.
2. In cases of an engine cut on take-off, crosswind take-offs and landings, the rudder would again appear somewhat more responsive.
3. It is possible that a small decrease in trim sensitivity might be noticed. This would probably be so in case of trimming out the rudder to hold asymmetric engine power.
4. Again, the incorrect spring would not effect the rudder channel of the auto-pilot, since the rudder servo motor drives the rudder directly via the torque tube and not via the spring tab mechanism.
5. The possibility of overstressing the rudder has been investigated. Even if the most severe B.C.A.R. manoeuvre case is considered (300 lbs. pedal force application by the pilot), the aircraft structure will not experience ultimate load conditions, but it is considered that some structural deformation could possibly occur. The case of an autopilot runaway would be as with the correct spring fitted, since the servometer does not control the rudder via the spring tab mechanism. The effect of the lighter spring would, however, make it slightly easier for the pilot to recover from the runaway condition.
6. The original flutter information for the aircraft type was reviewed and it is considered that the incorrect spring fitted would not cause flutter within the normal speed envelope for the aircraft.

It should also be noted that the damage to the fin, rudder and tab structure recovered was indicative of their being on the aircraft at impact and that no evidence was uncovered to suggest the presence of any damage or defect which would have prevented normal operation.

<u>11.5. Aileron Control Run in the Wings</u> The items recovered on the port side were: Two short lengths of control rod attached to the aft portion of the swinging link. A 9’ length between the engines which was attached to the wing. The rods were unbroken but bent and forced outwards beyond the normal movement. The control run local to the port aileron which was loosely attached to a portion of the wing T.E. member and an outer portion of the aileron. Included in this were the skew bar and housing, torque tube and lever, and about 8’ of the control rod and the servo tab actuating mechanism. The mechanism was displaced and damaged and the rods were broken.

The items recovered on the stb'd side were: An 11' length between engines 3 and 4. The rods were broken but about half the length was in position and this had been forced outwards beyond the normal movement. The control run local to the stb'd aileron comprising 12" of control rod attached via the lever to the aileron torque tube and skew bar. The assembly was loosely attached to a short length of the wing trailing edge member and the skew bar and housing had broken away from the aileron. No aileron structure was recovered.

11.6 Position of Control Rods

An attempt was made to establish control surface settings as given by:-

a. The positions of the centre rods under the pilots floor,
b. The protrusion of the rods from under floor beam at stn. 282,
c. The protrusion of the aileron rod at the back of the main spar,
d. Roller guide indentations on the aileron control run close to the port aileron.

and the results are summarised below.

Rudder:-	Position	(a) Full right rudder
		(b) corresponds approx. with position (a)
Elevator:-	"	(a) Overtravelled slightly beyond full up elevator,
		(b) Overtravelled in a down elevator direction,
Aileron:-	"	(a) Stb'd aileron partially up
		(b) Close to the neutral position
		(c) Stb'd aileron approx. fully down.
		(d) Stb'd aileron approx. half down.

11.7 Trim Circuits The elevator and rudder trim circuits were intact in the pedestal down to and including the sprockets and chains below the pedestal, some cable was also attached. The spilned drive shafts between the sprockets were missing on both circuits but the elevator trim servo drive was located. Some lengths of control cable were recovered and also four of the pulley groups down the fuselage.

The items recovered in the tail cone area were the portion of the rudder trim circuit attached to the torque tube and the upper portion of the wervo trim mechanism in position in the fin and rudder structure. The aileron trim tab on the stb'd wing is electrically actuated and the only item recovered was the indicator in the pedestal.

11.8 Trim Positions

Rudder The indicator in the pedestal gave rudder trim close to the neutral position. By dimensional check of a fixed point on the trim actuating rod with a reference point on the rudder torque tube, a trim tab angle of two divisions port tab was indicated. One or both ends of the system were affected during break-up and it was therefore impossible to establish the likely trim position before impact.

Elevator The setting obtained from the pedestal was 2 ½ units nose down. This reading is abnormally high but because of the lack of corroborating evidence and the fact that the setting may have altered during break-up no reliance can be placed upon it.

Aileron No evidence available.

11.9. Control Lock System The mechanism in the pedestal was complete. Also located was the control run back to the wing and along both wings to the No. 3 flap beams. The remainder of the system was missing with the exception of one gust lock arm on the port side which was attached to the outer aileron.

The lever in the pedestal was in the stowed position (i.e. locks off).

11.10 Control Stops None were recovered.

11.11. Summary of Conclusions No evidence was found to suggest the presence of pre-impact damage or malfunction, but since most of the control runs were not recovered the possibility of some defect in them contributing to the accident cannot be eliminated.

During examination of the rudder torque tube it was found that the wrong type of spring had been fitted. The effect of this on the rudder/tab operation was fully investigated and it was concluded that it had no bearing on the accident.

Attempts were made to establish the control surface settings at impact from the damage and position of the control rods recovered. These were found to be contradictory on the elevator and aileron and the rudder position conflicts with the evidence obtained from examination of the fin and ruder structure.

The trim settings obtained from the pedestal are regarded as unreliable since they may have been affected during break-up.

Section 12 Fuel System - Wing & Nacelle Installation

The disruption of the wing structure at impact caused severe damage to the fuel system. The bladder cells were torn apart and the portions recovered were attached to the wing structure. A substantial amount of piping from the refueling, interconnect, flow, and ventilating systems was recovered and some of this was in position in the wings and nacelles.

Items recovered from the fuel flow system:

> The boost pumps from the No. 4 tank
> Power drain valve – closed
> Both inter-engine valves, - actuators missing, valves open
> No. 4 engine low pressure valve with actuator – open
> Flowmeter mounted in No. 4 nacelle, 8 pacitor tank units
> 2 drip tubes, one differential switch and one low pressure warning switch.

The fuel pumps were within the isolation chambers and attached to pieces of the lower wing skin. Examination revealed no rotation marks on either of the units and it was concluded that at the time of impact they were not under the influence of electrical power.

The valve settings noted are correct for en-route flight.

Refuelling and Defuelling System The defuelling valves from the inner tanks were recovered. The port valve was closed but the stb'd valve was partially open. It was considered that this had been caused by impact forces.

The pressure refuelling connection was in position on the stb'd wing but missing on the port side, and two of the float switches were recovered.

Venting System Two of the float valves were recovered. The sealed floats in these were crushed probably due to water pressure in the sea-bed.

Summary of Conclusions The valve settings noted are normal for en-route operation and examination of the bladder cells, plumbing and units recovered revealed no signs of pre-impact leakage, fire or malfunction which may have restricted the fuel supply to one or more of the engines.

The fuel taken aboard prior to departure from Cork was 1000 galls. 290 galls. in each of the outer tanks and 210 galls. in each of the inner tanks. Estimates show that at the time of the last message, and assuming normal operation, the fuel content would have been approximately 110 galls. in each inb'd tank and 275 galls. in each outer tank. At this stage one boost pump is switched on in each outb'd tank and the remaining boost pump operating in each inb'd tank is switched off. The evidence obtained from the two pumps recovered indicates that this in fact had not taken place prior to the accident.

Section 13 Hydraulic System

The hydraulic system supplies the necessary power for retraction and extension of the landing gear, for operation of main wheel braking and nose wheel steering. The following items were recovered:

From hydraulic cupboard;

Header tank and attached filter
U/c selector valve and actuator
Hand pump
Emergency change over valve
By-pass cock
Associated piping, non-return and relief valves.

From nose area.

Hydraulic service panel, badly damaged. No indicator reading could be obtained.
1 H.P. filter and 2 micronic filters.
Automatic cut-out valve.
The main accumulator and one brake accumulator.
Brake control valve, maxaret on-off valve and portion of parking brake cable attached to the crew floor.
The four foot brake actuators. The pilots left hand actuator was badly damaged.
2 pressure reducing valves for brakes.
Steering selector valve minus operating and follow-up mechanism.
Steering jacks, portions of 2 way relief and shut off valves and associated piping were recovered with the nose leg.
Nose u/c jack and dampers attached to the oleo and portion of the top beam. The jack was fully extended, i.e. u/c retracted position.

From port main u/c areas

Maxaret system and brake assembly recovered with wheels and inner cylinder.
Jack and damper in position. The jack was extended, i.e. u/c retracted position.
Brake lines and walking joints attached to the outer cylinder.

From stb'd main u/c area

Jack and damper in position. The jack was extended and badly bent, i.e. u/c retracted position.
Brake lines and walking joints attached to the outer cylinder.

In addition to the above most of the piping from all parts of the aircraft were recovered, these included joints, some pressure transmitters, non-return and choke valves. In general this was entangled in the wreckage and some dismantling was necessary. The engine driven pumps were not recovered.

Summary of Conclusions Examination of the components recovered revealed no evidence of fire, pre-impact defect or abnormal operation in the hydraulic system.

The landing gear lever selector in the pedestal gave u/c down but the control valve and actuator and the position of the jacks indicated u/c up. The evidence clearly indicates that the nose and main u/c were fully retracted at impact and it is probable that the pedestal selector was displaced by impact forces.

Section 14 Air Conditioning & Pressurisation System

The following items were recovered attached to the wing and/or nacelle structure:-

No. 2 Engine: Air intake, filter and ducting from aft of the main spar up to the primary silencer.

No. 3 Engine: Ducting from the compressor to the primary silencer.

No. 4 Engine: Air intake, filter and some of the ducting attached to the T.E. member. A 5' length of the ducting outb'd of No. 3 nacelle had broken away but the remainder from the No. 4 nacelle to the primary silencer was attached.

The remaining items recovered are listed below. These had broken away from their mounting structure.
One compressor (serial No. missing, not possible to identify).
Two primary silencers (port and lower stb'd) and one secondary silencer.
The three spill valves and the actuator from No. 3.
A cabin pressure non-return valve.
Cockpit heat valve.
A portion of the intercool – valve and associated operating mechanism.
Temperature control gear and mounting structure (fixed under the floor at stn. 630). The actuator was missing but the control and manual over-ride mechanisms, micro switches, Desynn transmitter were attached.
The pointer was on the dividing line, between Intercool and Refrigerate.
The large dual heat exchanger unit with local pieces of outlet pipe attached.
Numerous bits of ducting.
Cabin Altitude indicator.
Cabin pressure controller attached to overhead panel.

Summary of Conclusions Damage to the items recovered was severe and the ducting badly flattened. During examination attention was directed towards any signs of overheating, contamination of ducts or lagging, leaks or excessive pressures which may have indicated abnormal operating conditions in the system. Nothing unusual in this respect was noted.

The housing of the ventilating fan and motor were recovered but the fan rotor was missing. The scoring inside the housing suggests that the fan rotor was rotating at impact. The fan is not normally driven when the aircraft is pressurised but the airflow would cause it to spin.

The cabin altitude indicator, and cabin pressure controller were investigated. Briefly the settings on the cabin pressure controller were normal, but the height indicator was damaged and the reading regarded as unreliable.

Spill Valve Settings noted:

	Switches	Actuators	Valve position
No. 2	Closed	-	Closed
No. 3	Auto	Open	Closed
No. 4	Close	-	Partially Open

These are contradictory and unreliable. Usually, spill valves are set to auto and start to open below 12,000’.

The cockpit heat valve was free and no information could be obtained from the intercool valve or the cabin pressure non-return valve. In conclusion it should be noted that investigation of the system revealed no evidence of faulty operation or defect prior to impact.

Section 15 Engine Fire Warning and Extinguisher System

The items recovered were: The four fire bottles, and two inertia switches at the No. 4 engine, breather pipe detector switches from engines 1, 2 and 3, the spray rings attached to the engines, pieces of piping and fire wire and the fire control panel mounted above the instrument panels.

The firing heads were attached to the bottles. The two inertia switches recovered were tripped but none of the bottles were discharged. The fire control panel P was severely damaged and no relevant information could be obtained from it.

The damage sustained by the spray rings, pipe lines and fire wire was consistent with the impact forces.

Summary of Conclusions It is considered that the systems were complete prior to impact. Although the two inertia switches recovered were tripped none of the fire bottles had been discharged. There were no signs of fire on the engines or nacelles.

Section 16 Thermal De-Icing System

The de-icing plating and exhaust outlets although damaged were still contained in the portions of the wing and fin structure recovered. The ducting down the fuselage was completely disrupted and the few portions recovered were distorted and flattened. The tailplanes and associated ducting are missing.

The unit at the No. 3 engine was not recovered but the one belonging to the No. 2 engine was mounted in position and included the heat exchanger unit, ducting, butterfly valves and operating actuator. The inching unit, from this assembly was found separately. Damage was severe, the heat exchanger unit was crushed, and the jet pipe was completely flattened. The actuator was fully extended, i.e. the butterfly valves open indicating that the de-icing from No. 2 engine was on.

The temperature indicator and associated rotary selector switch were in position in the overhead panel. The pointer indicated 150ºC, the knob was missing from the selector switch spindle but it was possible to establish a selection to stb'd. The two control switches had parted from their mountings and were retained by wiring both were in the off position. The overhead light filaments were broken and no useful information could be obtained from them. The wing inspection light switch was in the off position.

Summary of Conclusions Examination of the components recovered did not reveal any signs of overheating, contamination, leaks, excessive pressure or anything to indicate abnormal operating conditions. Both control switches indicated off but this information must be regarded as unreliable. However, it was possible to establish from the actuator recovered that the unit from the No. 2 engine had been selected on, and since No. 3 engine was apparently operating normally at impact it is probable that the unit associated with this had also been selected on.

Section 17 Electrical System

Introduction

Viscount EI-AOM was fitted with 4 engine driven six Kilowatt direct current generators whose output was fed to a common bus-bar. Undervoltage and overvoltage protection was provided.

Four 24 volt batteries arranged and connected in parallel are fed on to a battery bus-bar to provide current for various purposes and also to feed selected emergency circuits in the event of complete failure of the main electrical system in the air.

The aircraft A.C. supply (Invertor system) was derived from two invertors each having a capacity of 3 K.V.A. with their output regulated to 115 volts 400 C.P.S. These invertors are known as the Normal and Auxiliary invertors.

The Normal invertor supplies all the services including the wind-screen Nesa glass, when this is selected to the low position. Selection of Nesa glass to the high position automatically starts the Auxiliary Invertor. For emergency purposes there is a 250V.A. invertor fitted. Three phase 208V A.C. power for propeller and engine de-icing was provided for by four 7.5 K.V.A. alternators. Although a substantial part of the electrical system from EI-AOM was recovered the majority of the components were broken from their mountings and in some cases virtually destroyed by impact forces and salt water immersion. All parts were contaminated by salt water, marine growth, sand and extensive corrosion.

D.C. Power Supply and Distribution Nos. 1 and 2 Generators were recovered, but there was no evidence of mechanical defects within the units recovered or of damage due to rotation, over-heating, arcing, etc. No evidence could be found in any of the generators to determine whether or not they were producing electrical power at impact.

All the generator switches were recovered: they were in the following positions:- No. 1 – ON; No. 2 – ON; No. 3 – OFF; No. 4 – OFF. Indications were that the switch toggles had been subjected to considerable abrasion and therefore possibly displaced during the period they were in the sea.

All four ammeters were recovered, no useful evidence could be obtained as they were grossly damaged. The electrical power cables were examined but apart from impact and salt water immersion damage there was no trace of pre-impact damage.

The main earths had come adrift from structure at impact, they showed no trace of burning or arcing or any other damage that could have occurred before impact.

Voltage Regulators Two voltage regulators were recovered, they were extensively damaged. It was not possible to test the units in any way but all damage was consistent with crash impact forces and there was no evidence to indicate that they were not serviceable before the crash.

Batteries None of the four batteries was recovered, but were sighted on numerous occasions on the sea bed at the accident site when the T.V. camera was lowered. The main cables from the batteries to the commoning blocks were recovered with the battery socket connectors still attached. They showed no sign of damage apart from crash damage. There was no evidence of acid corrosion in the surrounding area or overheating.

Circuit Breakers The circuit breakers recovered were examined and found to be open circuited. It is considered that this is consistent with other accident findings where high impact forces and gross distortion of structure occurs.

Wiring Wiring from all parts of the aircraft up to the rear pressure bulkhead was recovered. It was examined for condition, electrical arcing, burning and overheating. All damage observed was consistent with impact forces and salt water immersion and there was no reason to believe that any wiring faults were in existence prior to impact.

Light Bulbs Numerous light bulbs from various locations in the cabin, cockpit and exterior were removed and samples sent for laboratory examination to see if it could be determined in what condition the bulbs were at impact.

Expert opinion on all the bulbs with the exception of the "No Smoking" light was inconclusive, however in the case of the "No Smoking" light it was suggested that this bulb failed "hot" under high G loading.

Invertor System None of the three invertors were recovered complete. The main Nesa glass power supply fuses Nos. 33 and 34 and the Turn and Bank fuse No. 21 were found. They were sent for laboratory examination. It was concluded from this examination that these three fuses had ruptured with power on. The Nesa glass is heated by power from the Normal or Auxiliary invertor dependent on whether the Nesa glass switch was selected to "High" or "Low".

The Nesa glass rotory control switch was recovered with the knob missing, the switch was selected to the "High" position. If the switch prior to impact was selected to "High" as found it would mean that both Normal and Aux. Invertors were running at the time the three fuses ruptured. (The Normal Invertor would have been supplying power for the Turn and Bank and the Aux. Invertor power for the Nesa glass on "High" selection).

For the invertors to run they require a power source of Direct Current. The laboratory findings in this case are important as they establish that there was both A.C. and D.C. power on the aircraft when the three fuses were ruptured.

Engine and Propeller Alternator System There were four alternators fitted on EI-AOM, none was recovered; most of the Alternator Control and associated wiring fitted in the four nacelles was recovered. It was examined and no damage was evident other than crash and subsequent damage. There was no evidence of overheating, burning, arcing, etc.

The switch position as recovered for the Propeller and Engine de-icing was as follows:- No. 1 – contacts adrift and toggle missing; No 2 – ON; No. 3 – ON; No. 4 – ON.

Summary of Conclusions It was possible by laboratory examination of fuses to establish that there was both A.C. and D.C. power on the aircraft at impact.

No evidence was found of burning, arcing or any other damage having been present prior to the crash.

Section 18 Radio and Instruments

The aircraft was fitted with two VHF communication receivers, type 618M-1D. The components recovered associated with the communications system were two controllers SN 29 and SN15 (Records). On examination it was observed that the controller associated with No 1 communications system had a frequency selection of 131.200 Mcs and No. 2 had a frequency selection of 132.475 Mcs. Power switches on both ends were in a position which would give good reception. Frequencies which would normally be selected are:- either 132.9 Mcs, 132.45 Mcs, 133.6 Mcs. or 131.15 Mcs.

Also fitted were two VHF navigation receivers, type 51RV1 and components recovered associated with the navigation systems were two controllers SN58 and SN68. The controller associated with No. 1 navigation system had a frequency of 113.35 Mcs. selected whilst No. 2 controller had a frequency of 114. 900 Mcs. selected. Frequencies which would normally be selected are:- 114.9 Mcs, 113.3 Mcs. or 113.1 Mcs.

Also fitted were two Automatic Direction Finders, type 7092. Both controllers associated with these systems were recovered and the frequency selection observed on the No. 1 controller was 1300 Kcs, and voice/range switch was at voice and the function selector at loop. The No. 2 controller had a frequency selection of 350 Kcs., the voice/range switch was at voice, and the function selector at loop. Frequencies which would normally be selected are so varied that it is impossible to pinpoint any particular one.

The aircraft was also fitted with a Marker navigation receiver, two compass navigation units and a Transponder navigation system, none of these systems were recovered.

The instrument components recovered were the cabin height indicator, cabin pressure controller, rate of climb indicator and a turn and bank indicator. A reading of 7000 ft. was shown on the face of the cabin height indicator. It cannot however be construed that this was the reading prior to impact since the indicator was badly damaged. The readings on the cabin pressure controller were correct for a differential pressure of 4.25 p.s.i. this being the pressure applicable to the aircraft. Readings noted were Pointer = 8,600 ft., Rate = Max., Aircraft Altitude = 18,000ft. The rate of climb, and turn and bank indicators were so severely damaged that no useful information could be obtained from them.

<u>Summary of Conclusions</u> To conclude it may be summarised that the components recovered and which were capable of examination were all found to be switched to normal operation in flight.

Prepared by J. McStay and M. Maxwell.

Appendix 4b

Appendix 4b Part 1

Investigation of Dart Mk. 510
Engines Recovered from Aer Lingus Viscount EI-AOM
Which Crashed on March 24th 1968

Service Department
Rolls-Royce Limited,
Aero Engine Division,
Derby.

ENGINE CONDITION REPORTS

No. 1 Engine exclusive of the Reduction gear.

Engine No. 5195 Time since new – 15,315.60 hours. Time since overhaul 3047.60 hrs. Last overhauled by Alfa Romeo on 3.5.66

Condition as received at Baldonnel :-

The whole of the front of the engine was missing right back to the intermediate compressor casing, with the exception of the nose cowl (which was amongst the loose wreckage salvaged), the 1st stage compressor diffuser guide vane ring (which was still retained on its ring of steel tie bolts), and the bulk of the reduction gear steel parts (which were attached to the No. 1 propeller recovered separately).

The major parts missing were spinner extension, reduction gear casing, air intake casing compressor inlet casing, torsion shaft, 1st stage compressor impeller and rotating guide vane on its shaft, the high speed pinion, the oil pumps and their associated drive shafts, and the oil cooler.

The 2nd Stage compressor shaft was sheared about one inch forward of the 2nd stage compressor rotating guide vanes.

The 1st stage compressor diffuser guide vane ring was still retained on its bolts. The nut had been stripped from one of the bolts, and all the bolts were bent to a greater or lesser extent, the direction of bend being generally in a downward direction and slightly to starboard. The guide vane ring itself was damaged and bent.

The front flange of the compressor intermediate casing had fractured round the bottom third of its circumference, and the rear flange for about a quarter of its circumference.

The fireproof bulkhead was detached, badly broken and twisted, but still round the engine. The tubular engine mounting was also still round the engine, though all the engine mounting feet were sheared from the compressor intermediate casing at the studs.

The three bottom combustion chambers were severely crushed, whilst the top four were relatively undamaged. The intermediate casing had completely corroded away, leaving the compressor and turbines connected solely by the turbine shaft. The nozzle box was crushed on the underside of the engine, and the exhaust unit was crushed almost flat in a downward and forward direction, pulled away from the engine somewhat, but generally in the correct position relative to the rest of the engine.

The turbine shaft was covered in white powder but appeared to be intact and coupled to the compressor. The LP turbine blades were all intact and undamaged and, despite crushing of the nozzle box, showed no visible bending from the outer shrouds.

The top rear fairing of the power plant into the wing, and about one square yard of the wing top surface were still attached to the engine through the mountings, bulkheads, etc.

The engine control box had torn from the engine, but was still attached to the power plant by severely bent and fractured control rods.

The fuel pump was still attached to the engine by the flexible fuel pipe, and though severely corroded its drive shaft was intact.

There was no sign of fire anywhere on the engine or around the mountings, bulkheads, etc.

Internal Strip Condition of No. 1 Engine.

The engine centre coupling (turbine shaft to 2nd stage compressor shaft) was connected, and it parted smoothly and easily.

All combustion chamber discharge nozzles were in good condition, as were the burners, the undamaged flame tubes, and the combustion outer casings.

The breather rotor was in its correct position and undamaged, but only held there embedded in a mass of white powder from the magnesium casings surrounding it, which had completely corroded away.

The 2nd stage compressor impeller and rotating guide vanes were in relatively good condition. At impact the rotating guide vanes had moved forwards slightly and fouled the eye casing. Five of the rotating guide vanes were out of full engagement with their respective impeller vanes, the worst being a full half an inch out of engagement at the tip.

The control box itself was relatively undamaged, broken away from the engine but still attached to a section of the fireproof bulkhead. All control rods were still attached to the box though not attached to their respective units. The control cross shaft was still attached to the control box though the casing through which it operates had completely corroded away and left it hanging free.

The nozzle guide vanes, as viewed through the discharge nezzles, appeared to be in good condition for the hours run, and the LP turbine blades appeared to be completely undamaged and with no apparent bend against rotation at impact.

No. 2 Engine exclusive of the reduction gear:-

Engine No. 2517. Time since new – 14, 601.60 hrs. Time since overhaul 384.60 hrs. Last overhauled by Rolls-Royce on 7.2.66.

Condition as received at Baldonnell:-

The general condition of the engine was very similar to that of the No. 1 engine.

Once again, the whole of the front of the engine was missing right back to the compressor intermediate casing, the only exceptions being the nose cowl (which in this case was still round the engine but forced back to the rear engine bulkhead badly twisted and broken through at the bottom), the 1st stage compressor diffuser guide vane ring (which was still retained on its ring of steel tie bolts), and the bulk of the reduction gear steel parts (which were attached to the No. 2 propeller recovered seperately).

The major parts missing were as for the No. 1 engine.

As in the No. 1 engine, the 2nd stage compressor shaft was sheared about one inch forward of the 2nd stage compressor rotating guide vanes.

The 1st stage compressor diffuser guide vane ring was still retained on its bolts. The six nuts from the top six bolts were sheared off and all the bolts were bent, the direction of bend being generally in a downward direction and inclined slightly to starboard.

The flanges of the compressor intermediate casing had not fractured (as had happened in the No. 1 engine).

The fireproof bulkhead was still attached to the engine though heavily buckled and torn. The tubular engine mounting was still attached to the engine though many of the mounting feet studs were sheared.

The three bottom combustion chambers were severely crushed, whilst the top four were relatively undamaged. The intermediate casing had completely corroded away, leaving the compressor and turbine connected solely by the turbine shaft. The nozzle box was crushed on the underside of the engine, and the exhaust unit was crushed almost flat in a downward and forward direction, pulled away from the engine somewhat, but generally in the correct position relative to the rest of the engine.

The turbine shaft was covered in white powder but appeared to be intact, and was coupled to the compressor. The L.P. turbine blades were all intact and relatively undamaged and, despite crushing of the nozzle box, showed no visible bending from the outer shrouds.

The top rear fairing, rear engine bay bulkhead, and a large piece of the wing structure were still attached to the engine and mountings together with parts of wing spars, wiring looms, control rods and other airframe debris.

The engine control box was pulled from the engine but the remains of severely bent control rods were still left on the engine. The control box itself was scarcely damaged but the rods were all bent and fractured.

There was no sign of fire anywhere on the engine or around the mountings, bulkheads, etc.

<u>Internal Strip Condition of No. 2 Engine.</u>

The engine centre coupling was connected, and it parted smoothly and easily.

All combustion chamber discharge nozzles were in good condition as were the burners, the undamaged flame tubes, and the combustion outer casings.

The breather rotor was undamaged and in the same environment as that on the No. 1 engine.

The 2nd stage compressor impeller and rotating guide vanes were in normal condition for the hours run. At impact the rotating guide vanes had moved forward slightly and fouled the eye casing. Six of the rotating guide vanes were out of full engagement with their respective impeller vanes, three of these being about ½" clear of their respective impeller vanes at the tip and the other three being somewhat less than this.

The control box was broken away from the engine but still attached to the control rods. The control cross-shaft was still attached and undamaged though the casing through which it passes had completely corroded away.

The nozzle guide vanes, as viewed through the discharge nozzles, were in a worse state than either of the other two engines with 4 or 5 burned through the leading edges and other burned to a lesser extent. The L.P. turbine blades had been rubbed evenly and quite heavily all round their trailing edges this being done by the exhaust unit when it was forced against them at impact, otherwise they were all intact. The blades however had no apparent bend against rotation at impact.

The L.P. fuel filter found with this engine was partly filled with sand. It was stained pink and contained a white gelatinous substance.

No. 3 Engine Exclusive of the Reduction Gear.

Engine No. 5839. Time since new 14,635.60 hrs. Time since overhaul 355.45 hrs. Last overhauled by Rolls-Royce on 7.11.67.

Condition as received at Baldonnell:-

The general condition of the engine was very similar to that of the Nos. 1 and 2 engines.

Again the whole of the front of the engine was missing right back to the compressor intermediate casing, the only exceptions being the nose cowl (which was amongst the loose wreckage salvaged) and the 1st stage compressor diffuser guide vane ring (which was still retained on its ring of steel tie bolts). In this case the propeller and reduction gear have not yet been recovered, so it is not known whether the reduction gear steel parts are with the propeller or not. Apart from this, the major parts missing were as for the No. 1 and 2 engines.

As in the Nos. 1 and 2 engines, the 2nd stage compressor shaft was sheared about one inch forward of the 2nd stage compressor rotating guide vanes.

The 1st stage compressor guide vane ring was still retained on its bolts. The bottom 7 nuts had been stripped from the bolts whilst the top 3 were still on their respective bolts and split pinned in position. The bolts were all bent, the direction of bend being generally in an upward direction.

As on the No. 2 engine the front flange of the compressor intermediate casing had not been fractured by impact.

The fireproof bulkhead was still attached to the engine though heavily buckled and torn, and the tubular engine mounting was still attached to the engine, though many of the mounting feet studs were sheared.

The three bottom combustion chambers were severely crushed, whilst the top four, once again, were relatively undamaged.

The intermediate casing had completely corroded away, leaving the compressor and turbine connected solely by the turbine shaft. The nozzle box was crushed on the underside of the engine, and the exhaust unit was crushed almost flat in a downward and forward direction, pulled away from the engine somewhat, but generally in the correct position relative to the rest of the engine.

The turbine shaft was covered in white powder but appeared to be intact and coupled to the compressor. The LP turbine blades were all intact and undamaged and despite crushing of the nozzle box, showed no visible bend from the outer shrouds.

The power plant rear bulkhead and engine mountings were still attached to the engine, but not to any wing components as was the case with the Nos. 1 and 2 engines.

The engine control box was attached and in position with all control rods badly bent or severed.

The fuel pump was still attached to the engine by the flexible pipe. Its casing had been smashed on impact. It was heavily corroded, but the drive was intact. The starter was also attached by its leads, and appeared relatively undamaged.

There was no sign of fire anywhere on the engine or around the mountings, bulkheads, etc:-

Internal Strip Condition of No. 3 Engine.

The engine centre coupling was connected, and it parted smoothly and easily.

All combustion chamber discharge nozzles were in good condition as were the burners, the undamaged flame tubes, and combustion outer casings.

The breather rotor was undamaged and in the same environment as those of the Nos. 1 and 2 engines.

The 2^{nd} stage impeller and rotating guide vanes were in normal condition for the hours run. At impact the rotating guide vanes had fouled the eye casing. Six of the rotating guide vanes were bent out of engagement with their respective impeller vanes. The worst of the six was fully out of engagement with the impeller vane at the tip; the other five were all still in partial engagement.

The control box was still attached to the engine and all the control rods were badly twisted and bent.

The nozzle guide vanes, as viewed through the discharge nozzles, were undamaged and in good condition with no sign of any deterioration. The LP turbine blades were all intact and undamaged.

The LP fuel filter was also found with this engine and was in identical condition with that on the No. 2 engine i.e. partly filled with sand, with some white gelatinous substance, and some pink staining.

No. 2 Engine Reduction Gear (Fully Stripped)
Part of this was still attached to the No. 2 propeller. The latter was removed under the direction of Dowty-Rotol Limited and the gear was then examined separately.

The part recovered consisted of the whole of the reduction gear back to and including the three layshafts and their rear bearings, but excluding the reduction gear casing the high speed pinion, the rear bearing panel, accessory drives etc.,

All magnesium parts had completely corroded away leaving the major steel parts relatively in their correct locations one to the other, and still in engagement.

The propeller shaft roller and thrust bearings were both undamaged and in surprisingly good condition for the time that they had been submerged in sea water. The propeller shaft itself and the annulus gear retaining webs appeared completely undamaged and in good condition.

The layshaft front bearings were in good condition considering the time immersed in sea water, as were all torque meter pads.

The three layshafts appeared to have been spread outwards at the rear and forced forwards relative to the annulus gear, and they had cracked the annulus gear in five places, the cracks roughly co-inciding with the position of engagement of the three layshafts as found. All layshaft teeth were undamaged other than heavy bedding of the teeth actually in engagement with the annulus gear. All annulus gear teeth were undamaged other than those actually in engagement with the layshafts, one of which had failed over the rear half of its length.

In each case the five major cracks in the annulus gear had run straight from the tooth root through the rear flange of the annulus gear and thence to the nearest lightening hole. There had been no crack propagation from one lightening hole to another.

<u>No. 1 Reduction Gear (Only Partly Stripped).</u>
Like No. 2 part of this was recovered attached to its relevant propeller.

The part recovered was exactly as for the No. 2 propeller i.e. the whole of the reduction gear back to and including the three layshafts and their rear bearings, but excluding the reduction gear casing the high speed pinion, the rear bearing panel, accessory drives etc.

As in the case of the No. 2 reduction gear, all magnesium parts had completely corroded away leaving the major steel parts relatively in their correct locations one to the other, and still in engagement.

The propeller shaft roller and thrust bearings were in similar condition to those from the No. 2 reduction gear. The propeller shaft appeared undamaged but the front annulus gear retaining web had cracked and torn through some 350º.

As in the case of the No. 2 reduction gear, the three layshafts appeared to have been spread outwards at the rear, and forced forwards relative to the annulus gear.

As far as could be seen without stripping, the layshaft and annulus gear teeth appeared undamaged.

The annulus gear had only two visible cracks where it had split from one of the teeth engaging with the port and starboard layshafts respectively, through the rear flange, and directly to the nearest lightening hole in each case.

<u>No. 4 Reduction Gear (Only Partly Stripped)</u>
This was recovered approximately one month before the reduction gears of No. 1 and 2 engine and hence the magnesium corrosion had not reached the stage of complete disintegration.

This reduction gear was attached to the No. 4 propeller and was more complete than those of the Nos. 1 and 2 engine. Quite a large part of the air intake casing had still not disappeared through corrosion, and in fact it had been attached to the No. 4 engine on the sea bed when located. It was this casing which parted when an attempt was made to salvage the engine and propeller complete by slinging from the propeller blades.

The damage to this reduction gear appeared to be somewhat less than the damage to the reduction gears from the Nos. 1 and 2 engines. The high speed pinion was in mesh with the three layshafts and was undamaged. The layshafts had not been spread as in the Nos. 1 and 2 reduction gears, and in consequence the annulus gear had not been split open. There was no damage to the propeller shaft or the annulus gear retaining webs.

The torsion shaft was recovered with the reduction gear and this was undamaged. It was subsequently crack tested and found to be entirely crack free.

In addition the nose cowl from the No. 4 engine was recovered. This was in a very similar condition to the nose cowls from the other 3 engines i.e. severely damaged round the bottom half and torn in half opposite to the oil cooler intake duct. There was, however a hole through it, adjacent to the outboard side of the oil cooler intake duct, from the inside to the outside. It is understood that when recovered this hole had through it part of the engine mounting.

DISCUSSION

It is considered that at impact all four engines were firmly attached to the aircraft. The evidence for this is twofold:-

1. Nos. 1, 2 and 3 engines were recovered in close proximity to the main aircraft wreckage; No. 4 was seen and its propeller recovered, from the same area;
2. Nos. 1, 2 and 3 engines were all attached to heavily impact-damaged mountings, parts of the power plant structure and in some cases wing parts. Though No. 4 engine was not recovered, it is understood that its propeller was damaged in a similar, if not identical manner to those from Nos. 1 and 2 engines (see separate report of Dowty Rotol Limited), and this would indicate that No. 4 engine was in a similar condition to No. 1, 2 and 3 engines at impact with the water.

From the general pattern of impact damage to Nos. 1, 2 and 3 engines it is evident that the aircraft was the right way up at impact, as all the heavy damage was to the underside of these engines. There was virtually no crushing impact damage to the combustion chambers either on the top or sides of these three engines.

It is difficult to accurately assess the degree of nose down attitude of the engines at impact, as the casings at the front of the engines, which could reasonably have been expected to give an accurate indication of angle of impact were all magnesium and had corroded completely away. However, the general impression gained, primarily from the remains of the air intake casing attached to the No. 4 reduction gear, was of a nose down attitude, possibly as steep as 45º. However a large part of this casing had also corroded away, this may or may not be valid.

The general damage to Nos. 1, 2 and 3 engines was remarkably similar. However, the No. 1 engine had a large part of the front and rear flanges of its intermediate compressor casing broken off, whereas the similar casings from the No. 2 and 3 engines had not. This is the strongest of the light alloy casings on the engine. From this, one would deduce that the No. 1 engine took more impact than the others, and that therefore the aircraft may have hit the water somewhat port wing first.

Nos. 1, 2 and 3 engines had all failed their 2nd stage compressor shafts close to the 2nd stage rotating guide vanes. The failures were all similar and were primarily in bending with some degree of torsion. It would seem likely that this occurred as the first propeller blade from each engine hit the water and was torn out in a rearwards direction, as had happened with the Nos. 1, 2 and 4 propellers. (See separate Dowty Rotol report). This would cause the engine to 'nod' downwards violently and momentarily impose a severe bending load on the section of the engine mounting points. This bending load would effectively be applied in the plane of the engine mounting points which corresponds closely with the plane of the shaft fractures.

This similarity in compressor shaft failures primarily tends to show that No. 3 engine also had its propeller attached at impact (though this propeller has not yet been located). It does not seem possible that this fracture in particular and the similarity of all the other impact damage to the Nos. 1, 2 and 3 engines, could have been achieved if the three engines had not been in a substantially similar configuration at impact.

All the engine evidence points towards the engines being at low power at impact, whilst the propeller evidence not only substantiates that, but confirms that they must have been turning as all three propellers recovered were on or about the flight fine pitch stop.

The low power evidence from the three engines was the complete lack of any turbine blade bend, and the relatively small amount of rotational bend of the 2nd stage rotating guide vanes, together with the unfractured, uncracked, torque shaft from the No. 4 engine.

The combination of propeller and engine evidence indicates that all four engines were at some low power condition at impact. The question of whether they were alight or merely windmilling is problematic. It was impossible to establish any control settings, as none of the FCU's were recovered with the engines and all control rods were badly bent, if not fractured by impact forces, and disconnected at one end from the cockpit and at the other from the appropriate unit. However, if the pilots were conscious immediately before impact, it is probable that the throttles would have been closed to minimise the force of impact by obtaining maximum propeller drag. If, on the other hand, lack of power had been caused by major engine failure or fuel starvation on more than one engine one would have expected at least two engines (one on either side) to have been feathered at impact. There was no such evidence.

Thus, it would seem reasonable to suppose that all four engines were alight but with the throttles closed, and the engines idling and the propellers windmilling on or about the flight fine pitch stops.There was no sign of fire anywhere on the Nos. 1, 2 or 3 engines neither was there any sign of fire in the wing structure behind all four engines.

There was no sign of any pre-impact failure within the recovered parts of engines 1,2 or 3. As all three 1st stage impellers and rotating guide vanes were missing from the three engines recovered, and as all three engines showed similar fractures of their 2nd stage impeller shafts, and as there is relatively little damage to the three intermediate compressor casings and 1st stage diffuser guide vane rings, it is considered that all three 1st stage impellers and rotating guide vanes were operating normally at impact.

Of the Nos. 1, 2 and 4 reduction gears so far recovered, Nos. 1 and 2 had cracked annulus gears. However in both these cases the three layshafts were still fully in mesh with their respective annulus gears so that no propeller disconnect had occurred. Furthermore, all teeth on both the layshafts and annulus gears were completely undamaged other than those actually in mesh in the 'as recovered' condition. Hence it is clear that all this damage was done at impact.

The fact that the reduction gears and annulus gears had not moved relative to each other after impact and consequent failure further substantiates a relatively low power, low speed condition at the time.

The fact that the No. 4 reduction gear was less badly damaged than those of the Nos. 1 and 2 engines (Annulus gear uncracked, layshafts not spread apart, and high speed pinion still in position) and that the No. 3 engine 2nd stage rotating guide vanes were deflected less than those on the Nos. 1 and 2 engines, tends to substantiate that the two port engines took most of the initial impact.

R.W.H. Quinton

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Appendix 4b Part 2

DOWTY ROTOL LIMITED

DYNAMICS DIVISION

REPORT NO. 5.13.3/2

Check Assessment of the Propellers
Installed on the Aer Lingus Viscount 803
Registration No. EI-AOM, which crashed
On 24th March, 1968 near the Tuskar Rock
In the St. George's Channel

DOWTY ROTAL Limited – Gloucester

ACCIDENT INVESTIGATION REPORT 5.13.3/2

Check Assessment of the Dowty Rotol Limited
Propellers Recovered from the Aer Lingus Viscount 803,
Registration No. EI-AOM, which crashed on
Sunday, 24th March, 1968 near the
Tuskar Rock in the St. George's Channel

This report and its conclusions are based upon the examination of the four propellers after their recovery from the accident area and shipment to the Aer Lingus Overhaul Facility, Dublin Airport.

Conclusions

1. The blade pitch angle at the moment of impact was 24º for all four propellers, i.e. each propeller was on the Flight Fine Pitch Stop.
2. All four propellers were intact, attached to their respective engines and rotating normally in a similar windmilling, low rotational speed condition.
3. The damage pattern on all four propellers is consistant with the aircraft being the right way up, possibly in a nose down attitude of not more than 45º, and having a very high rate of descent at impact.
4. Two possible operating conditions are indicated by the condition of the damaged propellers:-
   i. Steady state with idling fuel flow and a true forward speed less than 130 kts.
   ii. Steady state with zero fuel flow and a true forward speed less than 200 kts.

   Although in this instance it has not been possible to establish which of these two conditions existed at impact, the most probable is considered to be engine alight with the throttle closed and idling fuel flow selected.

- There was no evidence of mal-assembly, fatigue or other mechanical or hydraulic failure in any of the propellers. Each propeller should therefore have been capable of normal operation up to the moment of impact.

R.H. Barnfield, R.H. Barnfield,
Investigation Engineer – Airworthiness,
Dynamics Division.

12th Dec. '69. Date

CIRCULATION T.I.D.

Mr. R.W. Sullivan, Chief Aeronautical Officer, Dept. of Transport and Power. (6)
Mr. B. Morris, A.I.B. Mr. J. Knight, B.A.C.
Mr. R.W.H. Quinton, R.R.L.
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* Summary Only.

Compiled – R.H. Barnfield
Approved
Dept. – Airworthiness
Date – 27.11.69

1. <u>Details of Propellers Installed on EI-AOM</u>

<u>Type R. 130/4-20-4/12E</u>

Starting Pitch Blade Angle 0º
Flight Fine Pitch Stop Blade Angle 24º
Feathered Blade Angle 84º 24'

<u>Propeller Serial Nos.</u>

Installation	Propeller Serial No.	Hours T.S.N.	Hours T.S.O.
Port Outer (No. 1)	130/57/212	14,055.50	2998.50
Port Inner (No. 2)	130/57/218	16,890	3263
Stbd. Inner (No. 3)	130/57/377	15,411.10	1008.10
Stbd. Outer (No. 4)	130/57/287	15,975.10	1559.10

<u>Propeller Blades RA. 25842</u>

Installation	Blade No. 1	Blade No. 2	Blade No. 3	Blade No. 4
Port Outer (No. 1)	A.92566*	A.92433	A.92723	A.92603
Port Inner (No. 2)	A.100725	A.99225	A.99226	A.99251
Stbd. Inner (No. 3)	A.93683	A.93792	A.93756	A.93697
Stbd. Outer (No. 4)	A.93881	A.93302	A.93904*	A.93176

* These two blades have not been recovered.

2. <u>General</u>

2.1 Blade positions are, as viewed from the front of the hub, 1,2,3 and 4 reading clockwise from No. 1 blade position, and the propeller is left hand tractor when viewed from the rear, i.e. the sequence of blade rotation is 4,3,2,1

2.2 All blade angles and stop settings in this report refer to the pitch angle at the 0.7 radius station.

3. Port Outer Propeller (No. 1). Serial No. 130/57/212

3.1 General

3.1.1 No. 1 propeller with a major portion of the engine reduction gear attached, Ref. Plate 1, was recovered from the main wreckage area approximately four months after the accident.

All the magnesium parts of the reduction gear casing had completely corroded away therefore it was not possible to establish whether the propeller had broken away from the engine at impact.

3.1.2 Blades Nos. 2, 3 and 4 were retained in the hub but blade No. 1 was detached and has not been recovered.

3.1.3 The three blades retained in the hub showed with varying degrees of severity similar general characteristics of axial bending into the pressure face with associated chordal fine pitch twisting, Ref. Plate 2.

3.1.4 The blade bearing retention threads in the hub port of No. 1 blade were sheared and damaged around the front of the hub, Ref. Plate 3, but were virtually undamaged at the rear.

3.1.5 Only a small portion of the spinner front shell which was still attached to the centre section was recovered. The centre section was locally crushed in the region of No. 1 hub arm, but was relatively undamaged between hub arms Nos. 2, 3 and 4.

3.1.6 The pitch lock mechanism appeared to be undamaged. External seals on the assembly were in a good condition and the oil was not contaminated, other than by sea water.

3.1.7 There were no significant damage marks in the bore of the main cylinder, on the cylinder backplate, on the barrel of the transfer sleeve housing or on the eyebolt link and sleeve assemblies. No. 3 link assembly was intact.

The transfer sleeve housing (which retains the cylinder assembly onto the hub) was correctly tightened into the hub and the tabs of the locking washer were intact and correctly located.

3.1.8 The main operating piston, piston liner and pitch stops were undamaged.

3.1.9 The four blade bearing lockpieces were attached to their respective locations on the cylinder backplate and were intact.

3.1.10 During the dismantling of the propeller, the main operating piston was found in a position equivalent to a blade angle of approximately 37º.

3.2 Salient features noted during the examination of the Port Outer (No.1) Propeller Blade and Bearing Assemblies.

3.2.1 No. 1 blade has not been recovered.

3.2.2 No. 2 Blade and Bearing Assembly.

i. Blade

Slight axial bend into pressure face at approximately 60% radius. Those faces of the blade root dogs normally loaded by a relative fine pitch twisting of the blade heavily indented, distorted and cracked.

ii. Bearing Assembly

Roller witness indentations on a section of the preload tracks with the major axis of damage approximately 210º measured in a clockwise direction from the front of the hub. A visual matching of these roller indentations established the blade angle to have been approximately 11º when they were produced.

The operating pin retaining bolts and dowel located in the bearing C.F. race had failed due to overloads produced by a relative fine pitch twisting and rearwards tilting of the blade.

3.2.3 No. 3 Blade and Bearing Assembly.

i. Blade

Axial bend through approximately 30º into pressure face at 45% radius. Light indentations on the faces of the blade root dogs normally loaded by relative fine pitch twisting of the blade.

ii. Bearing Assembly

Light roller witness indentations on blade bearing tracks. A more detailed analysis of these roller indentations was performed at Dowty Rotol Limited – Ref. Appendix 1, to establish pitch angle at impact.

Operating pin attached to bearing C.F. race.

3.2.4 No. 4 Blade and Bearing Assembly

i. Blade

Pronounced smooth axial bend along length of blade through approximately 120º into pressure face with associated chordal fine pitch twist. Those faces of the blade root dogs normally loaded by a relative fine pitch twisting of the blade heavily indented, distorted and cracked.

ii. Bearing Assembly

No significant roller witness indentations on the tracks of either the preload or C.F. races.

The operating pin retaining bolts and dowel located in the bearing C.F. race failed in shear due to overloads produced by relative fine pitch twisting and rearwards tilting of the blade.

3.3 General Analysis – Port Outer Propeller (No. 1)

3.3.1 The general pattern of axial bending into the pressure face with associated chordal fine pitch twisting, exhibited by all three blades retained in the propeller hub, is characteristic of damage produced by impact loads on a windmilling propeller.

The pattern of bending and twisting of No. 4 blade, with no evidence of its having hit other structures, is consistent with the deformation having been produced by heavy hydro-dynamic loads such as would be encountered by a rotating blade being suddenly and totally submerged in water.

3.3.2 The pattern of damaged blade bearing retention threads in hub port No. 1 and the condition of the blade bearing lock piece is consistent with No. 1 blade having been pulled out of the hub by a rearwards bending of the blade, and is indicative of a high propeller Advance Ratio, i.e. a low rotational speed relative to forward velocity. This feature is also consistent with a windmilling condition.

3.3.3 The relatively undamaged condition of the spinner centre section between Nos. 3 and 4 blades is indicative of negligible propeller rotation after initial impact, suggesting low rotational energy.

3.3.4 The linkage of No. 2 blade ruptured at impact. The equivalent blade angle of 11º evaluated from the roller witness marks on the tracks of the bearing therefore does not reflect blade angle at initial impact but only confirms that impact loads twisted the blade fine. (That significant changes in blade angle can occur before blade bending loads transmitted through the bearing rollers can produce witness indentations is an observed and established feature when blade linkage is broken)

However the linkage of blade No. 3 had remained intact and by comparing bearing race distortion, the individual depth of roller indentations and their respective positions using a Rank Taylor Hobson Talyrond, it was possible to establish the pitch angle of the blade was 24º at impact. Ref. Appendix No. 1.

3.3.5 The position of the main operating piston as found during dismantling is not considered, by itself, to be an indication of blade angle at impact. In this propeller particularly, blade angle at impact is believed to have been correctly derived from No. 3 blade bearing, and the variance between this angle and the angle obtained from piston position is considered to have been due to subsequent movement of the piston after impact. This movement could have been caused by hydro-dynamic loads turning blade 3 after impact, or could have occurred during recovery and transport operations.

3.3.6 There was no evidence of mal-assembly or pre – crash or pre-crash mal-functioning in the propeller.

4. **Port Inner Propeller (No. 2). Serial No. 130/57/218**

4.1 General

4.1.1 No. 2 Propeller with the whole of the reduction gear attached (Ref. Plate 4) was recovered from the main wreckage area approximately four months after the accident. The condition of the reduction gear and casings was very similar to those of propeller No. 1 and likewise it was not possible to establish whether the propeller had broken away from the engine at impact.

4.1.2 Blades Nos. 2, 3 and 4 were retained in the hub, but blade No. 1 was detached and was recovered approximately five months after the accident.

4.1.3 The three blades retained in the hub showed similar damage to those of propeller No. 1, namely general characteristics of axial bending into the pressure face with associated chordal fine pitch twisting, Ref. Plate 5.

No. 1 blade also showed these characteristics, but in addition had sustained damage to the leading edge, caused by the blade apparently striking other wreckage debris.

4.1.4 The blade bearing retention threads in the hub port of No. 1 blade were sheared and damaged around the front of the hub but were virtually undamaged at the rear, similar to No. 1 hub port of No. 1 propeller. In addition there were two clearly impressed witness marks of the blade bearing spanner location dogs on the top face of the hub port at the rear.

4.1.5 The spinner front shell was detached from the centre section and not recovered. The centre section was locally severely crushed in the region of No. 1 hub arm.

4.1.6 The transfer sleeve housing was detached from the hub centre, although the tabs of the locking washer were intact and correctly located. Maximum thread damage was adjacent to the No. 1 hub arm position. There were no markings on the housing barrel.

4.1.7 The spinner abutment flange on the main operating cylinder was broken by rearwards bending in line with No. 1 hub arm. There were no other significant markings in the cylinder or on the cylinder backplate.

4.1.8 The pitch lock mechanism appeared to be undamaged. Visible seals on the assembly were in a good condition and the oil was not contaminated, other than by sea water.

The main operating piston, piston liner and pitch stops were undamaged, but there was local staining on the flight fine pitch stop from contact with the spring collet fingers in line with No. 4 eyebolt.

4.1.9 The four blade bearing lock pieces were undamaged and correctly attached to the cylinder backplate.

4.1.10 During the dismantling of the propeller the main operating piston was found in a position equivalent to a blade angle of 24º

4.2 <u>Salient Features noted during the examination of the Port Inner (No.2) Propeller Blade, Bearing and Link Assemblies.</u>

4.2.1 <u>No. 1 Blade, Bearing and Link Assembly</u>

i. <u>Blade</u>

Axial bend through approximately 60º into the pressure face at 35% radius with an associated chordal fine pitch twist. Pronounced curl of leading edge section of blade into pressure face, (i.e. fine pitch twist) outboard from 75% radius with an associated severe scuffing on the suction face. Leading edge severely damaged between 30% and 75% radius.

ii. <u>Bearing and Link Assembly</u>

The retaining bolts securing the operating pin to the C.F. bearing race had failed in overload produced by fine pitch twisting and rearwards tilting of the blade.

4.2.2 <u>No. 2 Blade, Bearing and Link Assembly</u>

i. <u>Blade</u>

Slight axial bend into pressure face at approximately 40% radius. Light indentations on the faces of the blade root dogs normally loaded by relative fine pitch twisting of the blade.

ii. <u>Bearing Assembly</u>

Visual correlation of light roller witness indentations on the tracks of the preload races showed the blade to have been in a negative pitch when the indentations were produced.

4.2.2 iii. <u>Link Assembly</u>

Operating pin attached to the bearing C.F. race but the locating dowel sheared by a relative fine pitch twisting – rearwards tilting of the blade.

No significant marks on the eyebolt link but the skirts at the rear end of the sleeve slightly deformed.

4.2.3 No. 3 Blade, Bearing and Link Assembly

i. Blade

Axial bend through approximately 30º into pressure face at 40% radius with an associated chordal fine pitch twist.

ii. Bearing Assembly

Very light roller witness indentations on the tracks of the preload races.

iii. Link Assembly

Operating pin attached to the bearing C.F. race but the locating dowel distorted by a relative fine pitch twisting – rearwards tilting of the blade.

Shank of the eyebolt link fractured by bending overload near the big end locating the operating pin. Associated damage witness marks on the rear skirt of the eyebolt guide bush.

4.2.4 No. 4 Blade, Bearing and Link Assembly

i. Blade

Axial bend through approximately 135º into pressure face between 40% and 60% radius with an associated chordal fine pitch twisting.

Those faces of the blade root dogs normally loaded by a relative fine pitch twisting of the blade all sheared.

ii. Bearing Assembly

Deep roller witness indentations on the tracks of the preload races. A visual matchcing of these indentations established the blade angle to have been 24º when they were produced.

iii. Link Assembly

The retaining bolts and locating dowel securing the operating pin to the bearing C.F. race sheared by relative fine pitch twisting and rearward tilting. of the blade.

4.3 General Analysis – Port Inner Propeller (No.2)

4.3.1 The general pattern of axial bending into the pressure face with associated chordal fine pitch twisting exhibited by all four blades and their link assemblies is characteristic of damage produced by impact loads on a windmilling propeller.

The severely bent and twisted blade No. 4 has very similar characteristics to the No. 4 blade of No. 1 propeller, and is consistant with No. 2 propellor rotating when its No. 4 blade was suddenly and totally submerged in water.

4.3.2 The pattern of damaged blade bearing retention threads, the condition of the blade bearing lock piece and the witness marks produced by the blade bearing dogs on the top face of the hub port at the rear are all consistent with No. 1 blade having been pulled out of the hub by a rearwards bending of the blade, and is indicative of a high propeller Advance Ratio, i.e. is compatible with a windmilling condition.

4.3.3 The relatively undamaged condition of the spinner centre section between hub arms 2,3 and 4 is indicative of negligible propeller rotation after initial impact, suggesting low rotational energy.

That the position of damage on the spinner, cylinder and the transfer sleeve housing threads was adjacent to hub arm No. 1, is significant when considered together with the evidence of propeller rotation and manner in which blade No. 1 was detached from the hub, since it suggests the aircraft was in a nose down attitude and had a high vertical velocity at impact.

4.3.4 The absence of damage on the cylinder backplate and the condition of the locking washer are indications that the transfer sleeve housing was correctly assembled and had been dislodged by impact loads on the cylinder assembly.

Impact of No. 2 blade occurred after the housing was dislodged. This is established from the analysis of No. 2 bearing roller indentations and the assessment of a negative pitch impact angle although the blade linkage was intact.

Likewise the fracture of No.3 operating link shank occurred after the transfer sleeve housing was displaced.

4.3.5 The assessment of a 24º pitch angle derived from the bearing indentations of No. 4 blade cannot be considered absolute proof of propeller pitch angle at impact, since the linkage of that blade was broken (See comment 3.3.4). However, the post impact conditions of Nos. 1 and 2 propellers were so similar it is reasonable to presume that the operating conditions of the two propellers at impact were also similar. Since it was possible to establish that the pitch angle of No. 1 propeller was 24º at impact, it is concluded that No. 2 propellor was also at 24º at impact.

4.3.6 There was no evidence of mal-assembly or pre-crash mal-functioning in the propeller.

5.1 **General**

5.1.1 No. 3 propeller with part of the engine reduction gear attached, Ref. Plate 6, was recovered from the main wreckage area approximately seventeen months after the accident. All the magnesium parts of the reduction gear casing had completely corroded away as with No. 1 propeller and likewise it was not possible to establish whether the propeller had broken away from the engine at impact.

5.1.2 All four blades were retained in the hub and showed with varying degrees of severity similar general characteristics of axial bending into the pressure face with associated chordal fine pitch twisting.

5.1.3 The spinner front shell was detached from the centre section and was not recovered. The centre section was locally severely crushed in the region of Nos. 3 and 4 hub arms, Ref. Plate 7, and was relatively undamaged in the region of No. 1 hub arm.

The lower half of the engine mounted brush gear housing had broken away and was not recovered.

5.1.4 Some of the aluminium alloy components of the propeller operating mechanism had been affected by salt water corrosion, the main operating cylinder being the most severely affected with a large section of the barrel having corroded away, Ref. Plate 7. Locally in this region of the cylinder there was also evidence of longitudinal cracks.

5.1.5 The pitch lock mechanism appeared to be undamaged other than from the affects of salt water corrosion. Visible seals were in a good condition.

Corrosion patterns on the abutment faces of the spring collet fingers and the flight fine pitch stop showed these components to have been in contact whilst the propeller was submerged, i.e. at this stage the propeller was on the flight fine pitch stop at 24º.

5.1.6 There were no significant damage marks on the cylinder back-plate, on the barrel of the transfer sleeve housing or on the eyebolt link and sleeve assemblies.

The transfer sleeve housing, (which retains the cylinder assembly onto the hub), was correctly tightened into the hub and the tabs of the locking washer were intact and correctly located.

5.1.7 The main operating piston, piston liner and pitch stops were undamaged other than from salt water corrosion.

5.1.8 During the dismantling of the propeller, the main operating piston was found in a position equivalent to a blade angle of 24º.

5.2 Salient features noted during the examination of the Starboard Inner (No. 3) Propeller Blade and Bearing Assemblies.

5.2.1 No. 1 Blade and Bearing Assembly

i. Blade

Slight axial bend into pressure face at approximately 35% radius with an associated chordal fine pitch twist. This blade was not taken out of the hub during dismantling.

ii. Bearing Assembly

Not dismantled. Operating pin attached to bearing C.F. race.

5.2.2 No. 2 Blade and Bearing Assembly

i. Blade

Pronounced axial bend into pressure face at approximately 40% radius with associated chordal fine pitch twisting extending outwards towards the tip.

ii. Bearing Assembly

Not dismantled. The retaining bolts securing the operating pin to the bearing C.F. race had failed in overload produced by fine pitch twisting and rearwards tilting of the blade.

5.2.3 No. 3 Blade and Bearing Assembly

i. Blade

Axial bend through approximately 90º along the length of the blade into pressure face with associated chordal fine pitch twisting. Leading edge severely damaged between 30% and 75% radius.

Those faces of the blade root dogs normally loaded by fine pitch twisting of the blade all sheared.

ii. Bearing Assembly

Blade askew in bearing due to rollers trapped between preload race thrust rib and centre race. Relative positions of the indentations produced by these trapped rollers show that during impact the blade twisted into a negative pitch.

A visual matching of deep roller witness indentations on the tracks of the preload races show the blade angle to have been 24º when they were produced.

Very light roller witness indentations on tracks of C.F. races.

The retaining bolts securing the operating pin to the bearing C.F. race had failed in overload produced primarily by rearwards tilting of the blade.

5.2.4 No. 4 Blade and Bearing Assembly

i. Blade

Pronounced axial bend into pressure face along length of blade with an associated chordal fine pitch twist. Slight damage on Leading Edge.

ii. Bearing Assembly

Visual correlation of deep roller witness indentations on the tracks of the preload races showed the blade had twisted fine at impact.

The operating pin retaining bolts and dowel located in the bearing C.F. race had failed due to overloads produced by relative fine pitch twisting and rearwards tilting of the blade.

5.3 General Analysis – Starboard Inner Propeller (No. 3)

5.3.1 The general pattern of axial bending into the pressure face with associated chordal fine pitch twisting exhibited by all four blades is very similar to the pattern of damage on the blades of Nos. 1 and 2 propellers; namely is characteristic of damage produced by hydro-dynamic loads on a windmilling propeller. That No.1 blade was relatively lightly damaged would suggest a low rotational energy.

5.3.2 Whereas one blade had been pulled out of its hub arm on each of Nos. 1 and 2 propellers, all the blades had been retained in No. 3 propeller hub. The reason for No. 3 propeller remaining intact may be due to a more even distribution of impact loads between the Nos. 3 and 4 blades, the individual loads being insufficient to wrench either blade out of hub but nevertheless being large enough to displace the blades in their bearing assemblies. The severe damage evident on the preload tracks of these bearing would suggest that only a small increase in bending loads would have pulled one or other blade out of the hub.

5.3.3 The pattern of damage on the spinner centre section relative to the severely damaged Nos. 3 and 4 blades, is consistent with a rapid submersion in less than one propeller revolution. This indicates a high vertical velocity, which from the locally relatively undamaged condition of the spinner centre section adjacent to No. 1 hub arm could be associated with an aircraft nose down attitude of not more than 45º.

5.3.4 From the damage pattern on the brush gear housing which is mounted on the engine reduction gear front cover it is evident that the aircraft was the right way up at impact, as the damage was on the underside of the housing.

5.3.5 It can be argued that the blade angle of 24º computed from the relative positions of the roller indentations of No. 3 blade bearing need not necessarily have been the blade angle at impact, since the blade linkage was broken. (See comment 3.3.4). However the general damage to Nos. 1, 2 and 3 propellers was so similar it would be reasonable to suppose that the three propellers were operating at similar conditions at impact.

It is therefore concluded that the blade angle of No. 3 propeller was 24º at impact.

5.3.6 There was no evidence of mal-assembly or pre-crash mal-functioning in the propeller.

6.1 General

6.1.1 No 4 propeller with an almost complete engine reduction gear attached, Ref. Plate 8, was recovered from the main wreckage area less than three months after the accident. The magnesium points of the reduction gear casing had not completely disintegrated, and the propeller with the reduction gear was attached to No. 4 engine when the power plant was located on the sea bed.

6. Starboard Outer Propeller (No. 4). Serial No. 130/57/287

6.1.2 Blades Nos. 1, 2 and 4 were retained in the hub, but blade No. 3 was detached and has not been recovered.

6.1.3 The three blades retained in the hub showed a similar pattern of damage to those blades retained in the hubs of Nos. 1,2 and 3 propellers, namely general characteristics of axial bending into the pressure face with associated chordal fine pitch twisting.

6.1.4 The blade bearing retention threads in the hub port of No. 3 blade were sheared and damaged around the front of the hub but were virtually undamaged at the rear, similar to No. 1 hub ports of Nos. 1 and 2 propellers. In addition there were three clearly impressed witness marks of the blade bearing spanner location dogs on the top face of the hub port at the rear.

6.1.5 Rather less than half of the spinner front shell was recovered with the propeller. This portion of spinner had been closely moulded around the cylinder, front cover and retaining nut.

The spinner centre section was locally crushed in the region of No. 3 hub arm but was relatively undamaged between hub arms Nos. 1,2 and 4.

6.1.6 The pitch lock mechanism appeared to be undamaged. External seals on the assembly were in a good condition and the oil was clean.

6.1.7 The spinner abutment flange on the main operating cylinder and the spinner backplate were broken by rearwards bending in line with No. 3 hub arm. There were no other significant markings in the cylinder or on the cylinder backplate.

6.1.8 The lower half of the engine mounted brush gear housing was broken.

6.1.9 The main operating piston and piston liner were undamaged, but witness marks matching with the abutment faces of the spring collet fingers were evident on the flight fine pitch stop.

6.1.10 The four blade bearing lock pieces were undamaged and correctly attached to the cylinder backplate.

6.1.11 During the dismantling of the propeller, the main operating piston was found in a position equivalent to a blade angle of 24º.

6.2 Salient features noted during the examination of the Starboard Outer (No. 4) Propeller Blade, Bearing and Link Assemblies.

6.2.1 No. 1 Blade, Bearing and Link Assembly

i. Blade

Slight axial bend into pressure face at approximately 30% radius with an associated chordal fine pitch twist.

ii. Bearing Assembly

Not dismantled.

iii. Link Assembly

The retaining bolts securing the operating pin to the bearing C.F. race had failed in overload produced by fine pitch twisting and rearwards tilting of the blade.

No significant marks on operating pin, link and eyebolt sleeve.

6.2.2 No. 2 Blade, Bearing and Link Assembly

i. Blade

Axial bend through approximately 90º along the length of the blade into the pressure face with an associated chordal fine pitch twist, particularly on the leading edge at the tip.

ii. Bearing Assembly

No significant damage to the tracks

iii. Link Assembly

The retaining bolts securing the operating pin to the bearing C.F. race had failed in overload produced by fine pitch twisting and rearwards tilting of the blade.

No significant marks on operating pin, link and eyebolt sleeve.

6.2.3 No. 3 Blade, Bearing and Link Assembly

i. Blade and Bearing Assembly

Not recovered

ii. Link Assembly

The retaining bolts securing the operating pin to the bearing C.F. race had all failed but the manner of failure was not established because the bearing C.F. race containing the shanks of the fractured bolts had not been recovered.

The bakelite bush which is fitted in the operating link and locates on the operating pin was cracked around the outer edge in a manner consistent with rearwards tilting of the blade. There were no other significant marks on the operating link and eyebolt sleeve.

6.2.4 No. 4 Blade, Bearing and Link Assembly

i. Blade

Slight axial bend into pressure face at 35% radius and into suction face at 60% radius with an associated chordal fine pitch twist, particularly along the leading edge towards the tip.

ii. Bearing Assembly

A visual matching of roller witness indentations on the tracks of the preload bearing showed the blade had twisted fine at impact. The major axis of the bearing damage was approximately 190º measured in a clockwise direction from the front of the hub.

iii. Link Assembly

The retaining bolts securing the operating pin to the bearing C.F. race had failed in overload produced by fine pitch twisting and rearwards tilting of the blade.

The bakelite bush which is fitted in the operating link and locates on the operating pin was crushed on the inner edge at the front, consistent with rearwards tilting of the blade.

There were no other significant marks on the operating link and eyebolt sleeve.

6.3 General Analysis – Starboard Outer (No.4) Propeller

6.3.1 The general pattern of axial bending into the pressure face with associated chordal fine pitch twisting exhibited by the three blades recovered with No. 4 propeller is very similar to the pattern of damage on the blades of the other three propellers and is characteristic of damage produced by hydro-dynamic loads on a windmilling propeller. That No. 1 blade was relatively lightly damaged would suggest low rotational energy.

6.3.2 The pattern of damaged blade bearing retention threads, the condition of the blade bearing lock piece, the witness marks produced by the blade bearing dogs on the top face of the hub port at the rear and the position of damage in the link bush are all consistent with No. 3 blade having been pulled out of the hub by a rearwards bending of the blade and is indicative of a high propeller Advance Ratio, i.e. is compatible with a windmilling condition. (rearwards tilting of the other three blades was indicated by their respective bearing or link assemblies).

6.3.3 The relatively undamaged condition of the spinner centre section between hub arms Nos. 1,2 and 4 is indicative of negligible propeller rotation after initial impact and is consistent with a low rotational energy and a rapid submersion in less than one propeller revolution.

The pattern of damage on the spinner front shell centre section and backplate and on the cylinder, all adjacent to the hub arm of No. 3 blade which was detached, is indicative of a high vertical velocity.

The overhaul damage pattern around the hub could be associated with an aircraft nose down attitude of not more than 45º.

6.3.4 The damage pattern on the underside of the brush gear housing is an indication that the aircraft was the right way up at impact.

6.3.5 The witness marks of the spring collet fingers on the abutment face of the flight fine pitch stop is an indication that the propeller was on or very close to the stop at impact, i.e. at 24º.

6.3.6 There was no evidence of mal-assembly or pre-crash mal-functioning in the propeller.

7. Summary and discussion of Results of Examination

7.1 The majority of the damage on the four propellers was by hydro-dynamic loading, although the detached blade No. 1 from No. 2 propeller and No. 3 blade of No. 3 propeller had both also been severely damaged by structural impact.

The chordal fine pitch twisting induced in the blades by the Impact loads is indicative that all the propellers were operating at negative aerodynamic incidence, i.e. that all four propellers were windmilling at impact.

The general damage pattern, indicative of low rotational energy was remarkably similar on all four propellers, although one blade had been detached from each of Nos. 1,2 and 4 propellers at impact whereas all four blades were retained in the hub of propeller No. 3

This discrepancy is considered to be of no significance and is attributed to slight differences in the distribution of impact loads on the propeller blades.

7.2 If it is postulated that one blade pulled out of its hub in flight, then an entirely different damage pattern to that found would have been produced in the hub port associated with that blade and the resultant out of balance forces would have detached the propeller from the engine. The subsequent propeller impact damage would have been entirely different to that on the propellers remaining attached to the engines.

Similarly if there had been a propeller disconnect and separation from the engine, an entirely different damage pattern would have resulted.

All four propellers are therefore considered to have been intact, attached to the engines, rotating and at the same operating condition at impact.

Although specific evidence of impact blade angle was obtained on only Nos. 1 and 4 propellers, it is believed that all four propellers were at the same pitch angle and on the Flight Fine Pitch Stop (24º) at impact.

7.3 The damage on the underside of the engine mounted Nos. 3 and 4 brush gear housings shows the aircraft was the correct way up at impact, and the close angular relationship between the first blade or blades to impact and the damage on the spinners, which was particularly noticeable on all four propellers, is indicative of a high vertical velocity. The damage on the spinners could be consistent with an aircraft nose down attitude of not more than 45º.

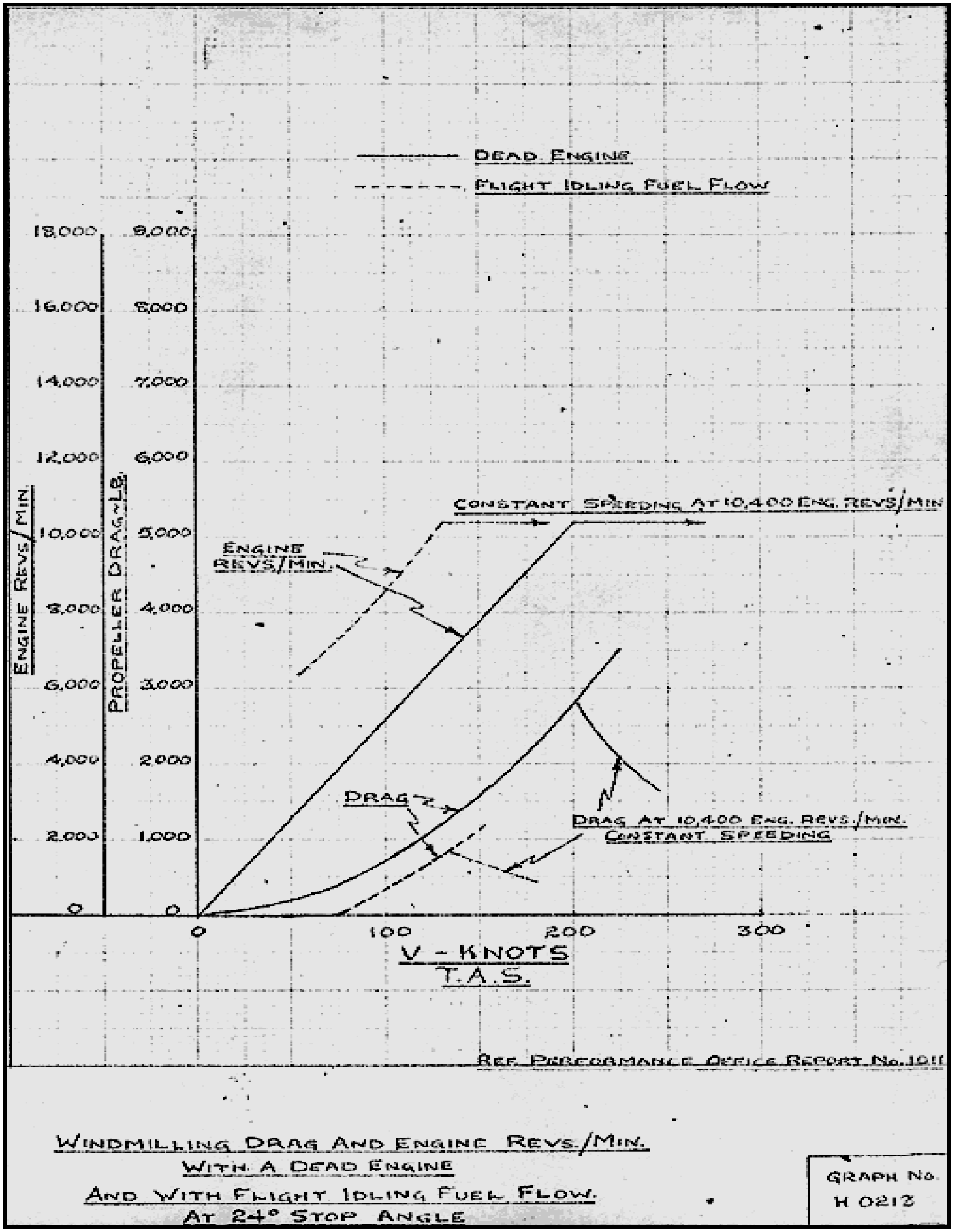
7.4 One of two possible operating conditions could be indicated by the foregoing conclusions:-

i. A steady state condition with idling fuel flow.
ii. A steady state condition with zero fuel flow.

It is not possible to ascertain from the condition of the propellers whether in fact the engines were alight. Consideration has therefore been given to evaluating propeller performance with idling fuel flow (approximately 275 lb/hr.) and zero fuel flow. For the purpose of these calculations forward speed is considered to be that producing an air flow normal to the propeller disc. The vertical component will not significantly affect the mean performance of the propeller.

The attached graph NO. H.0213 shows the values of windmilling drag and engine revs/min. Vs forward speed for 10,400 selected engine revs/min. for I.S.A. Sea Level conditions with approximately 275 lb/hr. and zero flow.

Graph No. H0213



7.4 From this graph it will be seen that the propeller will be on the flight fine pitch stop (24º) at speeds up to 130 kts. and 200 kts. T.S.A. for flight idling and zero fuel flows respectively.

If it is postulated that for some reason there had been a loss of power on all four engines, then assuming D.C. power had been available, auto-feathering should have been initiated and one would have expected at least one propeller on each side to have been in feather. There was no such evidence of this condition in any of the propellers.

On the other hand, the configuration with each propeller on the flight fine pitch stop and flight idling fuel flow selected is not unreasonable, since the pilot may well have closed his throttles before impact. Had this in fact been the case the propellers would have moved onto the flight fine pitch stops some 3 – 4 seconds after throttle closure.

Plate 1

Plate 2

Plate 3

Plate 4

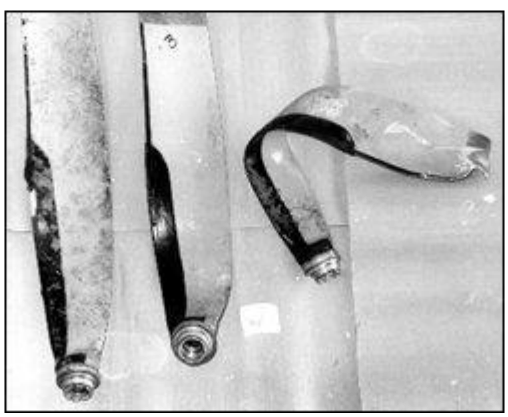


Plate 5

Plate 6

Plate 7

Plate 8

APPENDIX 1

Analysis of roller indentation postions on a blade bearing preload and centre race fitted to a Type R.130 propeller, Serial No. 130/57/212

Identification

Preload Race RA. 59401 Serial No. 16134/R
Centre Race RA. 59400 Serial No. 16134/R

Introduction

The two races were part of the bearing assembly fitted to blade NO. 3 Serial No. A.92723 of No. 1 propeller Serial No. 130/57/212 installed on the Aer Lingus Viscount EI-AOM which crashed in the St. George's Channel on 24th March, 1968. The races were returned to Dowty Rotol Limited for assessment of the blade angle at impact.

Conclusions

An equivalent blade angle of 24º 24' is obtained by using the etched reference marks and from matching the indentations on the bearing preload and centre races.

Since the etched reference marks were aligned 'by eye', it is concluded that the propeller was on the Flight Fine Pitch Stop (24º) at impact.

R.H. Barnfield,
Investigation Engineer - Airworthiness,
Dynamics Division.

12 Dec '69 Date

Details of Examination

1. Reference marks had been etched on each race during dismantling of the propeller, showing the relative positions of the blade operating pin to the preload race and the front of the hub to the centre race.
2. Bearing race distortion, the individual depths of roller indentations and the positions relative to the reference marks on the races were measured using a Rank-Taylor-Hobson Talyrond. The resultant plots are shown on Fig. 1.
3. To correlate the indentations, the trace obtained from the preload race must be considered as a mirror image. A graphical interpretation of the results is shown on Fig. 2.

Using the graph and trace, matching indentations on the bearing tracks were identified, and the angular positions measured. The result showed the operating pin position to be displaced 90º clockwise from the front of the centre race.

4. The geometry of the blade linkage of a Type R. 130 propeller is shown in Fig. 3, as viewed on the end of the blade root. This shows an operating pin position of 90º to be equivalent to a blade angle of 24º 24'.

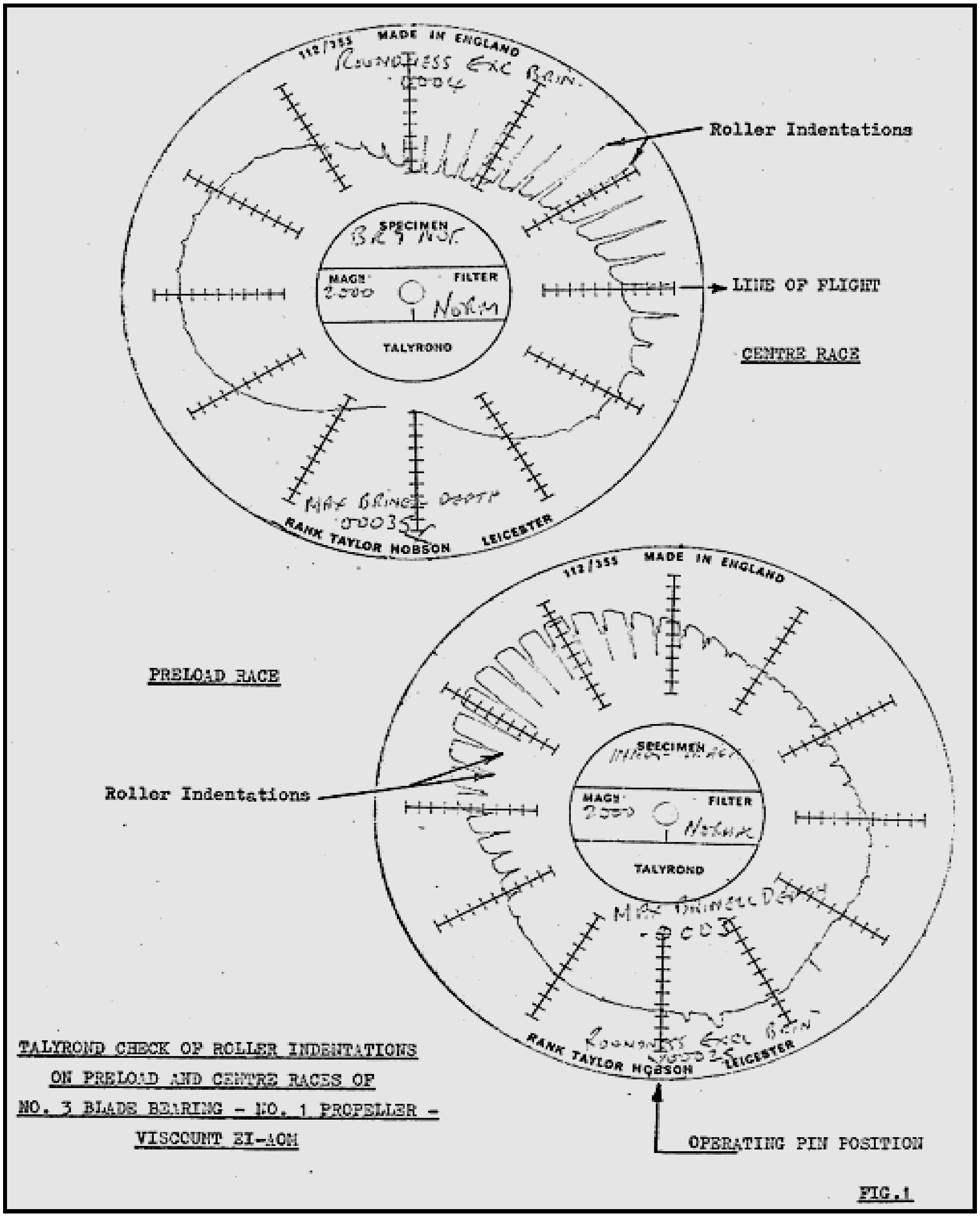


Figure 1

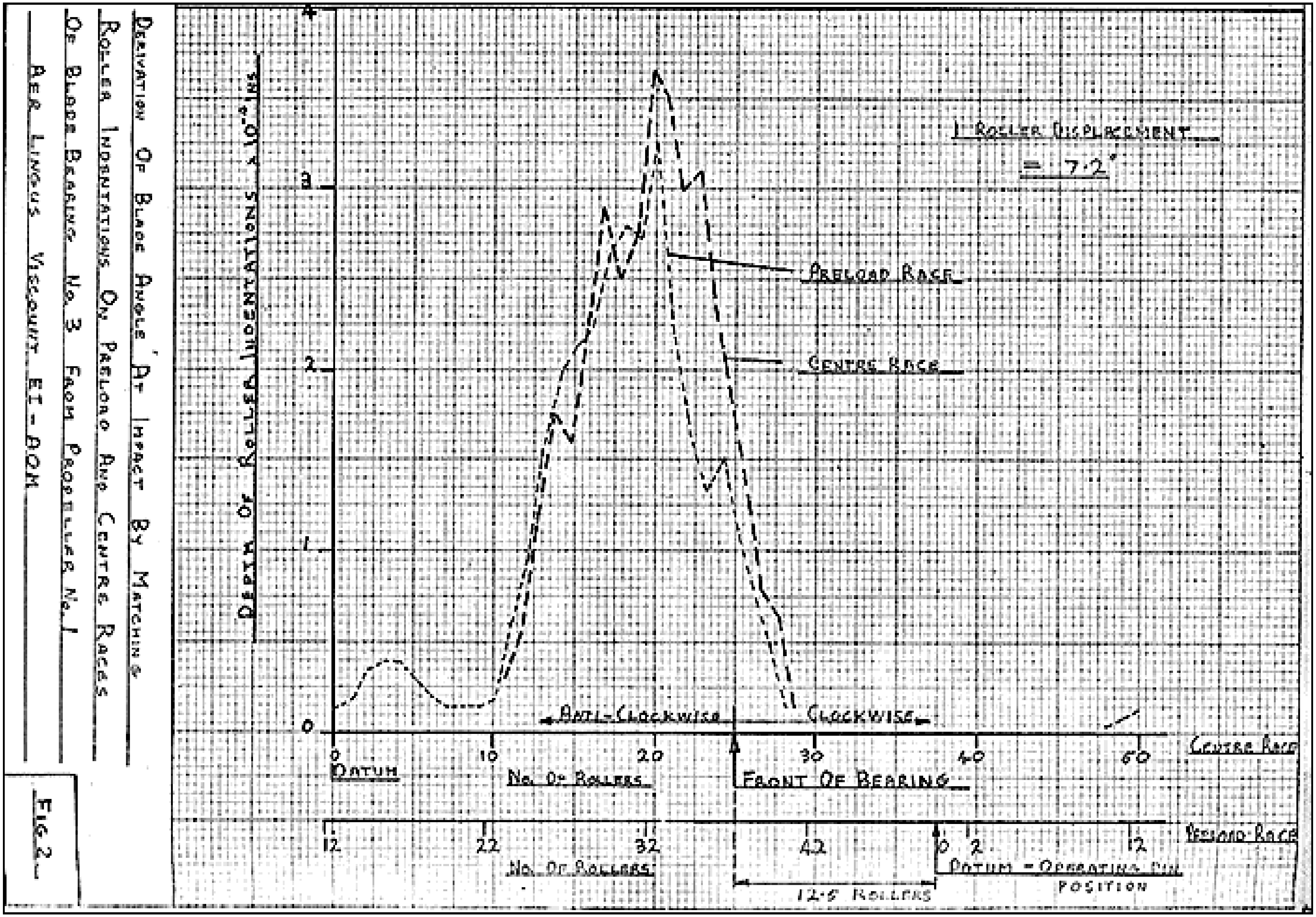

Derivation Of Blade Angle At Impact By Matching
Roller Indentations On Preload And Centre Races
Of Blade Bearing No 3 From Propeller No 1
Aer Lingus Viscount EI-AOM
Fig 2
Depth Of Roller Indentations x10⁻³ ins
1 Roller Displacement = 7·2°
Preload Race
Centre Race
Anti-Clockwise
Clockwise
0
1
2
3
4
0
10
20
30
40
60
Centre Race
Datum
No. Of Rollers
Front Of Bearing
12
22
32
42
0
2
12
Preload Race
No. Of Rollers
Datum = Operating Pin Position
12·5 Rollers

Figure 2

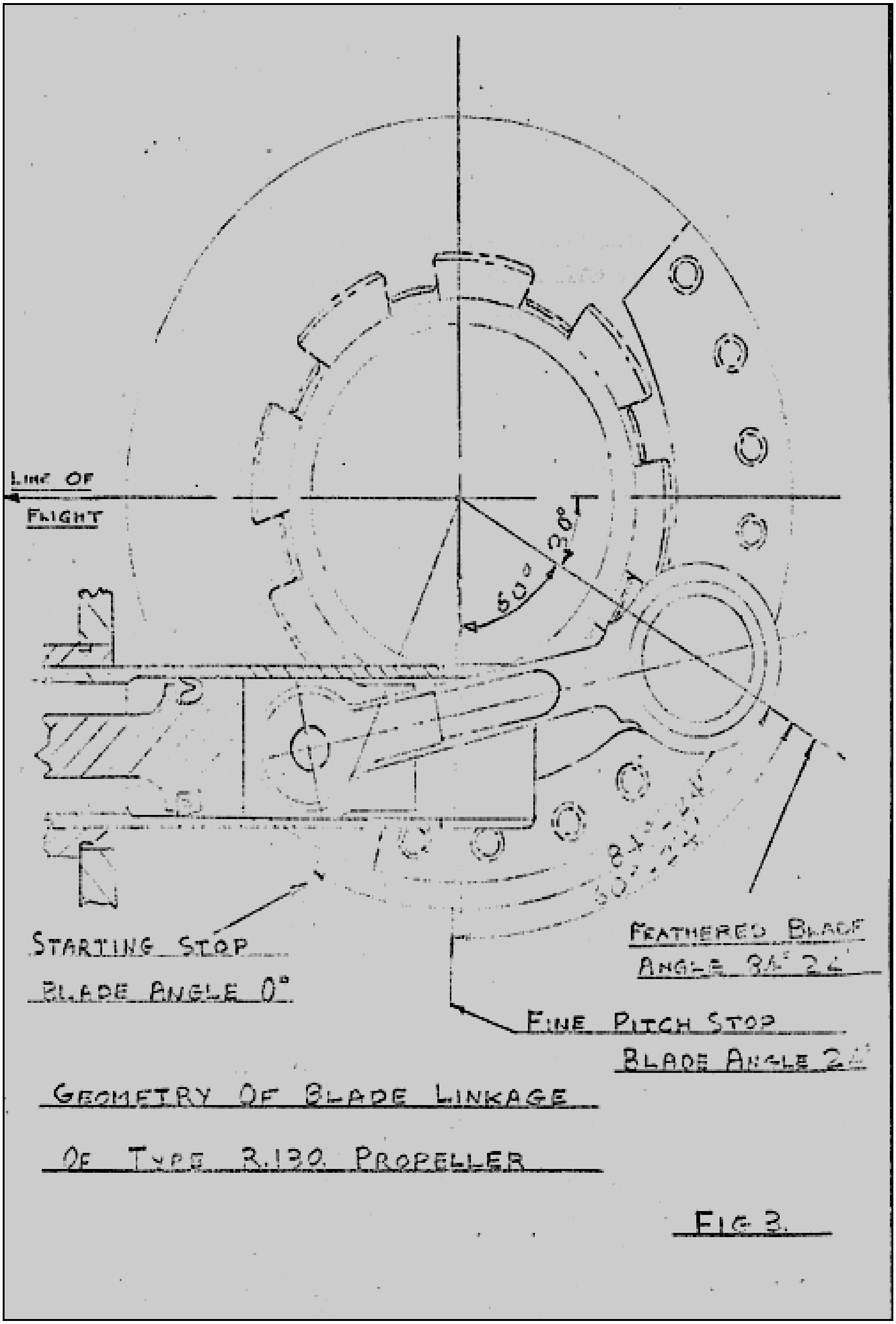

LINE OF FLIGHT
30°
60°
STARTING STOP
BLADE ANGLE 0°
FEATHERED BLADE
ANGLE 84° 24'
FINE PITCH STOP
BLADE ANGLE 24°
GEOMETRY OF BLADE LINKAGE
OF TYPE R.130 PROPELLER
FIG 3.

Figure 3

Appendix 5

Examination of S.E.P.2. Autopilot

5.1 An examination of components of the autopilot – a Smiths S.E.P.2 was done at Dublin Airport on 21st October, 1968.

1. Heading Selector Code No. ISMT

   Mod. No. 1

   The Serial No. of this item from the aircraft records was 1125, however the Serial No. engraved on the dial was 2127A.

   The Compass Card was reading 65º and the Select Heading Pointer was set at 120º. The instrument was badly damaged and both the above indications were frozen. It is considered that these were the positions of the two indications at impact. No other evidence was obtained from this instrument.

2. Flight Panel Code No. 245.EAP

   Serial No. 1099/57

   The three channel switches were switched 'in' and the contacts were closed. The Power Height Lock, Beam and Glide switches were in the off position but were free to operate and would have relaxed to the 'off' position when the power supply was lost. The Pitch Switch was central but was free to be moved. The Turn Control was fully clockwise but was not frozen in this position. The 'Ready' light bulb was removed for examination but evidence of lighting at impact inconclusive.

3. Safety Switching Unit Code No. 270.EAP

   The data plate had been damaged and the Serial No. obliterated.

   The relays were extensively damaged and no useful evidence could be obtained.

4. Heading Control Unit Code No. 230.EAP

   Serial No. 1125 Mod. Nos. 1 & 2

   This item was contaminated due to exposure to the sea water. The fuses were intact.

5. Aileron Servomotor.

   The only part of this item recovered was the MK. 4 Plug & Socket with a section of aircraft cable identified J11 and a number of internal Servomotor leads attached to the socket. The ends of three of these leads (pins K,M and C) had globules on their extreme ends.

These had originally been diagnosed as fusing which had occurred when the leads were torn from the Servomotor with power on. Further microscopic examination however showed that they were in fact the soldered joints where the leads had been connected to the windings of the motor and generator.

Engage and Trim Indicator
The trim movement was missing and the Engage Flags were broken away from the movements. Only one flag was found. No useful evidence was noted.

7. Trim Servo Motor Code No. 259.EAP
Serial No. 1100/57

The Clutch assembly was in a satisfactory condition. The clutch, motor and brake were electrically in a satisfactory condition. Although the assembly had suffered some corrosion due to exposure to the sea water, there was no evidence of pre-crash damage.

8. Amplifier Unit Code No. 275.EAP
Serial No. 1115

This item had been extensively damaged and only certain items were in a condition which warranted further examination.

a. Link Panel

This was in a reasonable condition, all the links were present apart from PR but there was evidence that this had been torn out of the 0.6 position. It was determined that the links were in the correct positions for the aircraft type.

b. Balance Potentiometers

The CF potentiometer was broken but the others were set as follows:

Rudder + 1 ½
Aileron - ½
Elevator - 1

c. Cooling Fan

The motor and fan runner were intact but the fan case moulding was broken. Where the case had been crushed on to the fan runner the fan blade ends had marked the moulding. The marks were in a form which showed that when the case crushed, the fan runner had been rotating.

d. Pitch Datum Potentiometer

Code No. HM20/2 Serial No. 621/6172

When the contact plate was removed the interior of the potentiometer was in a clean and dry condition but the internal components were not in their normal position. During a continuity check of the potentiometer the winding was satisfactory but the wiper contact was open circuit for approximately one third of the travel from the anti-clockwise (nose down) end. The other two thirds of the travel were giving intermitted contact. One slip ring contact of the wiper plate EAP 6403 was bent down to a point where it would not make contact with the slip ring EAP 604.

The other slip ring contact was incorrectly formed and lifted so that it would have excessive pressure on the slip ring. The outer turn of the anti-backlash spring HSC.2832 was deformed radically. The three contact wiper wires were not lying in line with each other and the tail of the wiper plate to which they are attached was bent down onto the moulding EAP.6441/M. The deformation of the wiper wires and plate had caused the loss of wiper contact pressure.

There were three sets of contact tracks on the potentiometer winding face. One set was in the centre of the track where the wipers would contact if correctly set up. The other two tracks were either side of the normal track and lined up with the deformed contact wiper positions.

It was considered that the deformation of the slip ring contacts and the anti-backlash spring would have no detrimental effect on the pitch datum motor operation. It was also agreed that this deformation could not have been caused during impact.

The deformation of the wiper wires was also considered to have occurred pre-impact but it was considered that the bend in the tail of the wiper plate may have occurred due to impact forces. Smiths Industries Limited carried out acceleration tests on a Pitch Datum Potentiometer. It was subjected to acceleration tests by two methods to determine the effects of excessive "g" loading on the potentiometer components. The wiper assembly was set so that the acceleration would act in a direction to bend the tail of the wiper plate as noted on the crash item. The P.D.M. was subjected to an acceleration test of 150g on a pneumatic cylinder decelerator giving a sinusoidal wave form. The wiper assembly was examined and no deformation had occurred. This test was followed by two further acceleration tests of 22g on a lead block decelerator giving a square wave pulse. Further examination showed that no deformation had occurred.

c. Pitch Datum Motor and Gearbox

The assembly was corroded due to exposure to sea water. The head of one of the screws which hold the gear box in the motor was missing allowing the flange joint to open. The gear box interior was severely corroded and as the head of the screw was not found it may have been removed by the action of the salt water. There was no evidence of pre-impact damage.

EFFECT OF A COMPLETE OPEN CIRCUIT P.D.M. POTENTIOMETER ON AUTOPILOT PERFORMANCE.

Although the contact in the P.D.M. was intermittent the worst case of a complete open circuit was considered under the various autopilot operating modes:

1. Autopilot disengaged.

The action of the Mercury Switch to ‘level’ the Pitch Platform would tend to be not quite as precise as designed but the degree of malfunction would be virtually negligible in its effect.

2. Autopilot Engaged.

   As the Autopilot was engaged, the prevailing pitch attitude of the aircraft could be affected by 1 above to the extent that it would be gently altered in one direction until the Gyro Pitch Platform became ‘level’. This, therefore, would be immediately reflected on the Rate of Climb indicator and the Pilot would use his Pitch Control to trim out to requirements. In using the Pitch Control, however, some sloppiness in achieving the desired pitch attitude would undoubtedly become apparent, because the nature of the fault under consideration deprives the pitch manoeuvring system of any precise ‘position’ control, and there would also be a tendency for the pitch rates on the ‘slow’ and ‘fast’ positions of the Pitch Control knob to be higher than normal.

3. Aircraft on climb-out under Autopilot control at 160 kts. IAS And 1000 ft/min. rate of climb – Height lock selected at 17000 ft.

   In addition to depriving the Autopilot pitch manoeuvring system of any ‘position’ control, as previously stated, the fault under review would also inhibit operation of the Height Integrator Amplifier when Height Lock mode was engaged.

   Under the flight conditions stated above, therefore, the first affect of the height error signal being developed would be to drive the Gyro Platform at a speed proportional to its magnitude to return the aircraft towards the ‘selected’ altitude. Therefore, however, because of the lack of height error integration, there would be no subsidence of the aircraft onto the ‘selected’ height, but passage through it and initiation of Autopilot pitch control in the opposite direction. In other words a Height Lock oscillation would develop.

   Without resort to special calculations using the aircraft derivatives, etc. it is not possible to predict exactly the subsequent nature of this phugoid motion. Nevertheless, neglecting the inertia effects of the aircraft and assuming that the Pitch Platform Amplifier always drives the gyro Pitch Platform at its maximum speed of 2.5º/sec. (nominal) for corrective action, then under these extreme conditions it is possible to show that the resultant Autopilot control would be to try and make the aircraft execute a pitch oscillation of 4.4 sec. Period with normal acceleration increments of +0.48 g being applied.

   Quite obviously the aircraft would not behave like this in practice and, even if it could, it would not be catastrophic. At this stage, therefore, only the following carefully considered prediction can be offered.

   The imposed oscillatory pitch motion would be initially milder than that quoted above but become slowly divergent. Without any doubt, therefore, the resultant effects of this on pitch attitude, airspeed and rate-of-climb, together with the induced 'g' increments, would thereafter alert any Pilot to take perfectly safe and short-term corrective action. It is also considered that, failing 'instinctive' disengagement of the Autopilot by the Pilot, the resultant change of trim being experienced by the Autopilot Elevator Servomotor would, in itself, very shortly effect an automatic 'cut out' via the Rotary Torque Limitor on this channel especially if the order of ± 0.5g increments were being incurred. (Note: The Automatic Alevator Trim System is 'lagging' and therefore assisting in this effect). Any reaction of the Pilot to try and 'override' the Autopilot by appropriate action on the Control Column would also produce equivalent results.

4. (a) Aircraft on climb-out under Autopilot control at 160 kts. I.A.S. and 1000 ft/min Rate-of-climb – Height Lock selected at 1000 feet.

   (b) Height error signal always causes pitch platform to run at 2.5º/sec (nominal maximum) until either,

i. Platform reaches limit (15º from level flight), or
ii. Height error reverses sign, in which case platform starts to run at 2.5º/sec in opposite direction, i.e. platform reversal occurs every time aircraft return to height at engagement of Height Lock.

At the same time, use has been made of experience of typical aircraft performance and the fact that some temporal lag is likely on the b(i) and (ii) conditions above due to manometric system lags and Autopilot pitch platform/serve response times. It should be noted that pressure error effects at the static vents could effectively increase or decrease these lags but this aspect remains in the 'unknown' category.

Throughout previous calculations the aircraft speed has also been assumed constant. This is not really justified. Actual speed variation must depend on pilot's throttle action on levelling out as well as speed variations due to dynamic motion of the aircraft.

The normal acceleration increment for a steady pitch rate may be determined from the product of the aircraft's speed and the rate of change of pitch attitude. The normal acceleration in a non-steady condition lags this value (based on instantanious rate of change of pitch attitude) because the acceleration is only developed after the aircraft has pitched to the new incidence.

Using a simple first order lag with a time constant of 1.5 seconds to represent the above case and remembering that there will also be some lag between platform rate and the aircraft pitch rate depending on the aircraft and the autopilot inner loop characteristics, the resultant calculations show that with an overall effect of all lags as being equivalent to a 2 second lag:-

(a) At time zero (i.e. engagement of Height Lock)

i. The aircraft pitch attitude will be the sum of its flight path angle, i.e. 2.7º (nose-up), plus 'incidence angle'.

(b) After time 4.6 secs.

i. The aircraft will have returned to the 'engagement height' with a rate of descent = 1600 ft/min.
ii. The pitch attitude will have altered 10.2º in a nose-down sense relative to the initial figure of para. (a) above, and the flight path angle = 4.3º (nose down).
iii. The 'g' increment experienced will have been – 0.43g.
iv. The pitch platform now reverses directions.

(c) After time 14.05 secs.

i. The aircraft will have again returned to 'engagement height' with a rate of climb = 3660 ft/min.
ii. The pitch attitude will have altered 10.7 degrees nose-up relative to the initial figure of para. (a) above, and the flight path = 9.9º (nose up).
iii. The 'g' increment experienced will have been + 0.47g

At this point it will be appreciated that if the motion were allowed to continue, the speed variation would become an important factor – the deceleration is probably of the order of 3 Knot/sec (or 5 ft/sec^2).

Without a more complex representation of the aircraft with actual characteristics and also without a defined throttle action, it is pointless to continue such calculations. However, as will be seen even from the most adverse ' practical' assumptions so far made, the 5 second duration times used in certificating the Autopilot with malfunctions of this order of magnitude have been well exceeded and, even then, safe manual recovery action should prove of no problem to the Pilot.

CONCLUSIONS

Although it was reported that the Autopilot Master Switch was in the "off" position when recovered, it is possible from the evidence of the Amplifier Unit Cooling Fan, that the system was energised at impact. The Master Switch is a toggle type and could have been changed over at impact. There is no evidence at this stage to show if the Autopilot was engaged at impact.

The deformed condition of the components in the Pitch Datum Potentiometer is considered to have been caused at some stage during the earlier life of the Amplifier. There is no evidence in Aer Lingus records of the Pitch Datum Unit being overhauled or replaced since the Amplifier was taken over from K.L.M. in early 1967. During its service with Aer Lingus it has not been reported defective in the elevator channel.

If the reported condition of the Pitch Datum Potentiometer had been a long standing fault during previous service there is no doubt that a history of Height holding complaints would have been recorded by the pilots.

The following repair record for the Amplifier has been traced:

1967	(as a 246 EAP)	Roll Oscillation	(Smiths)
		(Converted to 275 EAP)	
Nov. 1958		Broken J4 Plug	(Smiths)
April 1967		Fitted to EI-AOJ	(Aer Lingus)
July 1967		Turn Intermittent	"
August1967		Fitted EI-AKO	"
Oct. 1967		Heading Errors	"
Nov. 1967		Fitted and Removed	"
		EI-AOE (No fault)	
Jan. 1968		Fitted EI-AOM	"

During the time between 1958 and 1967 the Amplifier was in service with K.L.M.

It is reasonable to assume that during its service from April 1967 until the 24th March, 1968 there was no electrical fault present on the Pitch Datum Unit. It is therefore considered that the intermittent open-circuit could have occurred at one of the following times:

a. Since the autopilot was disengaged after use on the previous flight
b. During impact, the already deformed condition being marginally worsened due to impact decelerations.
c. Due to some surface contamination on the potentiometer winding surface during the 6 months immersion in sea water.

The latter case is the more reasonable explanation. The deformation of the contacts had left them with reduced contact pressure. The Potentiometer Assembly is not heremetically sealed and during its immersion in salt water the surface of the Potentiometer track would be chemically if not visually contaminated. The effect of these two conditions would give rise to intermittent open circuits.

If the intermittent open circuit had occurred prior to the final manoeuvre of the aircraft the worst effect would be to rotate the aircraft at a maxium rate of approximately 2 ½ degrees per second and up to a maximum pitch angle of 15 degrees.

This would only occur in the Height Lock mode but the effect would be limited in any case within the safety limit of the aircraft by the Pitch Channel Rotary Torque Limiter. The effect would be reduced by the inertia of the aircraft and by the fact that the potentiometer was not completely open circuit.

It is considered that the effect of the Pitch Datum Potentiometer, if it was in a defective condition during flight, is fully encompassed by the B.A.C/Smiths/ARB Autopilot Airworthiness Certification trials carried out on the Viscount 800 series aircraft and therefore would not cause the aircraft to assume an unsafe attitude.

Nevertheless in order to determine more precisely the consequences of the defect it was decided to perform a flight test on a Viscount which had been modified so that an open circuit of the P.D. Potentiometer could be introduced at will.

The test flight took place on 12th May 1969 and the report is contained in section 5.2 of this Appendix.

5.2 Flight Test Report No. VISCOUNT 803/1/69

Introduction

The objective of the tests was to establish the effect to the aircraft of the failure, or an intermittent function of, the Auto Pilot Pitch Datum Potentiometer (PDP). As the precise sequence of EI-AOM's pitch control and height lock selections is not known, the tests included various methods of Auto Pilot controlled transition from climb to cruise, inserting a PDP malfunction as required. For this purpose, a specially modified Auto Pilot Amplifier was used which gave a facility enabling the PDP to be isolated or re-instated by selection from a switch positioned on the Flight Deck.

Instrumentation

An accelerometer mounted vertically on the coaming panel attached to the right hand side of the left windscreen pillar.

A modified SEP 2 Auto Pilot amplifier, type LS/FC/2746, giving a remotely controlled PDP 'normal' 'isolate' facility.

Loading

The aircraft was loaded to 60,150 lbs. (27,373 Kg) with the Centre of Gravity 436.6 inches aft of datum, allowing 5 crew on the Flight Deck and 3 persons in the main cabin. Full fuel, 1938 galls., and 1200 Kg of ballast was carried. The ramp weight and CG quoted above are similar to the pre flight condition of EI-AOM prior to the accident.

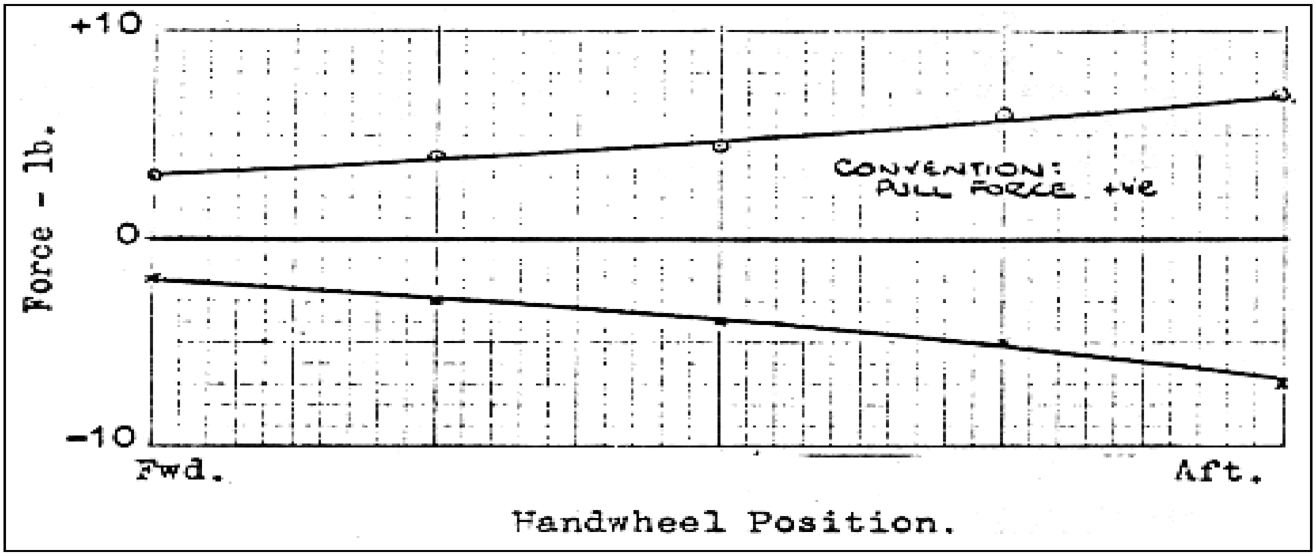
Weather

Broken cloud build-ups to FL 200. All the tests were carried out VMC and in smooth air.

Flight Test Report No. VISCOUNT 803/1/69

Note: All the 'Test Nos.' subsequently referred to in the text apply to the Flight Test Schedule No. VISC/251/803.

Ground Tests:	Test No.
With the springs disconnected, the elevator circuit frictions were:	3.2



With the Auto Pilot engaged, the forces to disconnect, displacing the handwheel against the A/P were:- 3.1

Pull +42 lb., Push – 40 lb.

Applying a pitch command against a static handwheel, the loads to disconnect were: Nose up 32 lb., Nose down 30 lb.

Auto pilot cut-out buttons were satisfactory. 3.3

Function of A/P Pitch control switch were normal with the PDP switch to isolate. 3.4

<u>Air Tests:</u>

Note: In the sketches produced below, apart from a common time base scale, no inference should be drawn regarding the magnitude of pitch angle or height gained or lost. The intention is to show the effect of each test graphically for reasons of clarity.

Flight Test Report No. VISCOUNT 803/1/69 Test No.

At 17,000 ft., an approach to the stall was made at 58,200 lbs. (26,350 Kg) in the configuration: 4.1

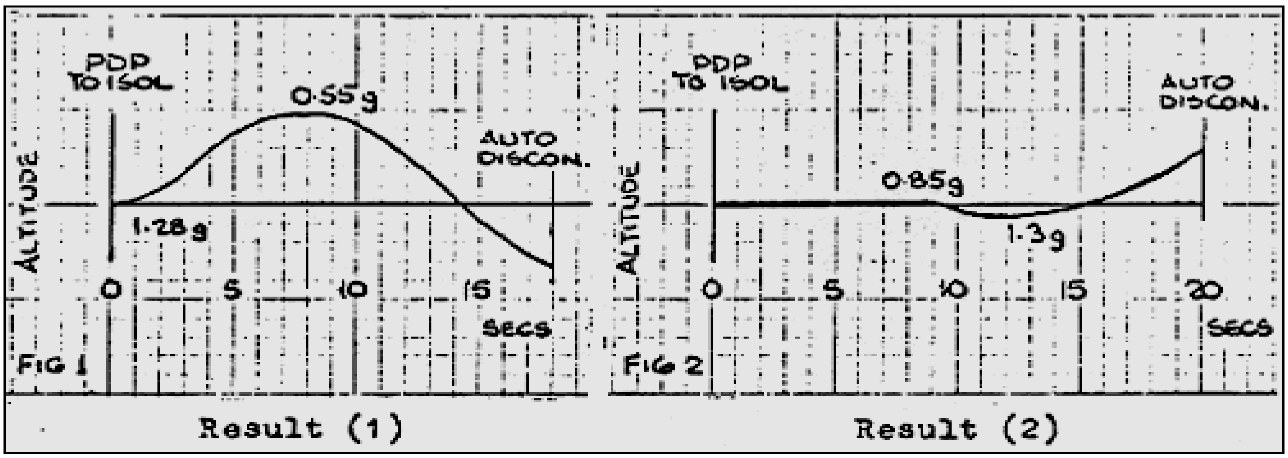
Wing flaps : 0 º
Undercarriage: Up
Power: Flight idle: and the speeds achieved were Buffett onset 115 kts., Stall warning 113 kts.
The Stall warning speed quoted in the Flight Manual at the test weight: 113 kts. I.A.S.

Test condition: At 17,000 ft., with the aircraft trimmed straight and level at 170 kts. I.A.S.. Power for level flight, with the A/P/ and height lock engaged, select the PDP switch to isolate.

Result (1) The aircraft firmly pitched nose up with a maximum ‘g’ of 1.28 and entered a climb of 1600 ft/min. maximum, followed by a nose down pitch of 0.55 total ‘g’, then an auto disconnect. The duration from PDP ‘ISOL’ selection to disconnect was 15 secs.

Result (2) For 9 ½ secs. the aircraft showed no reaction, then, after a mild nose down pitch of 0.85 g, a firm nose up pitch of 1.3 g followed by an auto disconnect.

The duration of the test was 20 secs.



Throughout each test, the altitude variation was 400 ft., and the speed variation within 7 kts. Power setting was 13400 r.p.m. 170 psi torque, which was not adjusted during the test.

Recognition of the onset of each runaway was immediately apparent and, in each case, there was no doubt that a manual disconnect would have been made immediately. Recovery from any attitude caused by the pitch oscillation, following a manual disconnect, could have been effected smoothly and without undue difficulty.

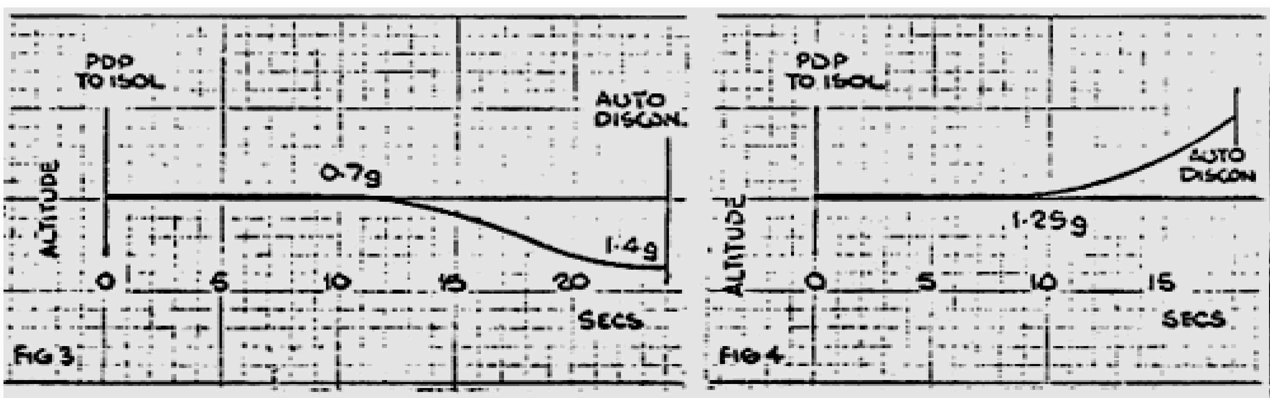
Flight Test Report No. VISCOUNT 803/1/69	Test No.
As it proved unnecessary to induce an upset, these tests were omitted.	4.2.3
	4.3.1
Test Conditions: At 17,000 ft., trim the aircraft in straight and level flight at 170 kts. I.A.S. with appropriate engine power, A/P and height lock engaged. Isolate the PDP and, after permitting a phugoid, reinstate the PDP at the top of the sinusoidal curve and permit the aircraft to rejoin the height lock datum.	4.4.1/2

Result (1) After the PDP ‘ISOL’ selection, the aircraft maintained the cruise condition for 10 seconds, then entered a nose down pitch with a minimum ‘g’ of 0.7 total and with a maximum rate of decent of -1300 ft/min.

This was followed by a strong nose up pitch of 1.4 g at which point the A/P auto disconnected. The duration of the test was 24 seconds.

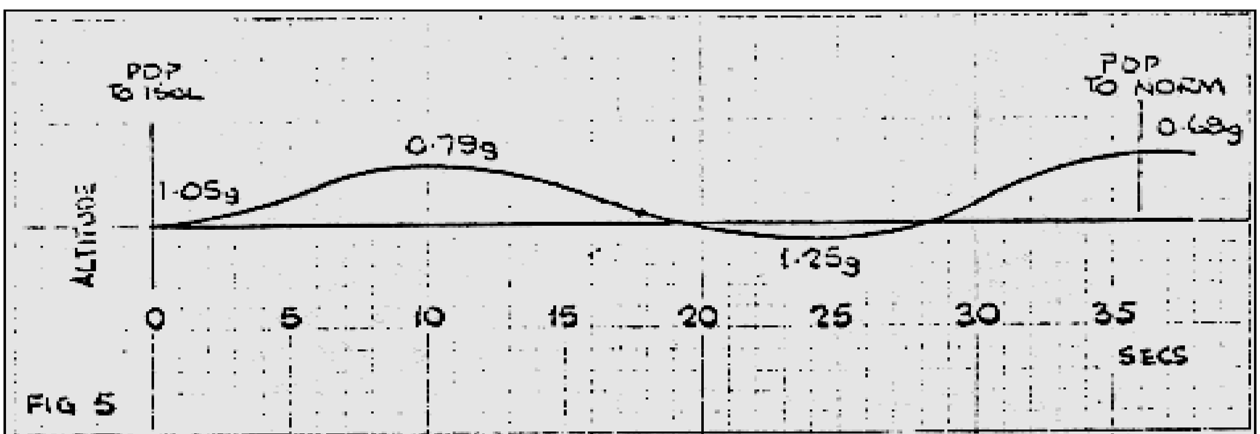
Result (2) At the time of the PDP selection to ‘ISOL’ , a negative stick force of approximately 5 lb., was being applied. A gentle nose up pitch of 1.05 g with an altitude gain of 600 ft., a nose down pitch of 0.7 g followed by a stronger N.U. pitch of 1.25 g. During the resulting climb, the PDP was returned to ‘NORMAL’ and this caused a N.D. pitch of 0.68 ‘g’ as the aircraft returned to the height lock datum. The duration to selecting the PDP to ‘NORM’ was 36 secs. 4.5.1/2

Result (3) The aircraft maintained the cruise condition for 9 seconds after the PDP was isolated, then pitched nose up with a max. ‘g’ of 1.25 and auto disconnected after climbing 700 ft. The duration to disconnect was 18 secs. 4.4.1/2



Result (1) Result (3)

Flight Test Report No. VISCOUNT 803/1/69 Test No.



Result (2)

As established during the earlier tests, recognition of a fault became very soon apparent and a manual disconnect would be made. Recovery from any attitude created by the oscillations experienced would present no difficulty, after a manual A/P disconnect.

Test Condition: From 17000 ft. straight and level, height lock disengaged and PDP isolated, using the A/P pitch switch and adjusting the engine power as required, enter a

climb condition of (a) 500 ft./min. 4.6.1/2

(b) 1000 ft./min. When established, re-instate the PDP. 4.7.1/2

Result (1) Immediately on selection of the PDP to 'NORM', at 15,500 ft., and at a climb rate of +500 ft./min., the aircraft pitched firmly nose up with a max. 'g' of 1.18 and the rate of climb increased to + 1000 ft./min. Power was not altered and the speed continued to reduce. At 30 seconds the speed was 138 kts., the minimum 128 kts. At 60 secs., after which the aircraft started a very shallow descent then levelled, accelerating slowly. At 90 secs. The speed was 135 kts. at 17,240 ft. and at 120 secs., 140 kts. at 17,300 ft.

Result (2) From an established rate of climb of 1000 ft./min. the re-instatement of the PDP caused a very mild nose up pitch of 1.05 g total and a consequent deceleration. From a start altitude of 17,200 ft., the speed dropped through 134 kits., 17,720 ft. at 30 seconds to a minimum of 129 kts., 17,950 ft. at 45 seconds, before commencing a slow acceleration, initially with a descent rate of –100 ft./min. to level flight. Speed and heights recorded were at 96 secs. 139 kts, 17,730 ft. and at 120 secs., 142 kts., 17,750 ft.

These tests indicated that they would certainly be much more difficult to identify, particularly if the pilot's attention was distracted. The oscillation, however, if left unattended, was shown to be very mild and stable, with a minimum speed of 1.29 Vsi before a slow acceleration was commenced.

Test Condition: With the PDP isolated, climb at 160 kts with appropriate engine power and at 17,000 ft., enter a level cruise condition using the A/P pitch controller. Simultaneously with the height lock engagement, re-instate the PDP.

Result (1) An immediate very slight nose up pitch before returning to height lock datum.

Result (2) Aircraft remained on height lock datum with no discernable pitch changes.

These tests showed that, on the height lock mode selection, sufficient authority was available to permit the auto pilot to function normally.

Pilot’s Comments – General.

Referring to Page 3, tests 4.2.1/2, as has already been stated, these were easily identified mainly by the ‘g’ experience, and both Pilots agreed that should this have occurred in airline flight, the auto pilot would have immediately been disconnected, and the runaway not allowed to continue, though should it have been allowed to do so, as can be seen from the results it in no way endangers the aircraft.

Moreover, on at least two occasions when the test switch was inadvertently pressed, it brought an immediate reaction from both pilots.

With regards the runaways 4.6.1/2 and 4.7.1/2, on page 5, the lack of ‘g’ as an "attention getter", meant that this type of runaway might be allowed to continue to its entirety. However, as can be seen from the results and comments, it once again did not place the aircraft in an embarrassing situation, and if allowed to run itself out would then only be recognised by the change in altitude or speed.

Flight Test Department,
British Aircraft Corporation
(Weybridge Division),
Bournemouth (Hurn) Airport.

14th May, 1969.

Flight Test Report No. VISCOUNT 803/1/69

Viscount – Auto Pilot Investigation.

Summary

Flight Tests, to Schedule No. VISC/251/803 were carried out on an Air Lingus Irish Viscount Type 803, registration EI-AOJ, to establish if any connection exists between the failure of the Auto Pilot Pitch Datum Potentiometer (PDP) and the accident to Viscount EI-AOM on the 28th March 1968.

The results obtained indicate that, under all the conditions of test, a failure or re-engagement of the PDP does not cause:-

a. Any condition of hazard to the aircraft,
b. that the total 'g' did not exceed 0.55 to 1.4, and
c. that during the stick free pitch oscillation, the minimum flight speed encountered did not fall below 1.29 VSI.

The test flight was made from Dublin Airport on the 12th May, 1969, the crew were as follows:-

Mr. E.D. Glaser, BAC. Pilot
Capt. A.O'Donohue, Aer Lingus, Captain
Mr. R.W. O'Sullivan, Dept. of Transport and Power
Capt. M. Carr, Dept. of Transport and Power
Mr. P. Corbett, Aer Lingus
Mr. R.W.G. Blair, Smiths Industries Ltd.
Mr. R. Cornock, Smiths Industries Ltd.
Mr. J.E. Gray, BAC.

Compiled by: [signature]

Int. Circ. App'd by: [signature]

Ext. Circ. App'd by: [signature]

Appendix 6

6.1 Summary of Witnesses' Statements

(Locations shown by numbers on map 6 – 6.2)

Witness No. 1 saw three small black clouds almost directly overhead. Saw an aeroplane come out of the clouds, going in a southerly direction, unsteady and apparently descending. Turned to right with very sharp angle of bank. In sight for about 30 seconds. No sign of fire or smoke. Time uncertain but well after 11.30a.m.

Witness No. 2 saw an aeroplane approaching a black cloud. Nose of aeroplane as far as the wings was in the cloud. Direction approx. that of the Saltees. (SE from witness' location). Cloud about size of large hay shed and seemed to be revolving round, and travelling away rather fast for a cloud. Noise was not significant to this witness, but the aeroplane and cloud appeared lower than normal. The cloud the aeroplane went into was not like normal clouds but was smokey coloured. About a minute later, after witness had gone indoors a loud bang like an explosion in a quarry was heard, which died away, like thunder. Time between 11.45 a.m. and 12.45 p.m.

Witness No. 2(a) heard sound but was not in position to see anything.

Witnesses No. 3 and 3(a) saw aeroplane going towards the Saltee Islands. The outer half of the left wing was "on fire", (no smoke), and a piece of the end of the tail. The aeroplane kept winding away to its right on towards Slade. It was still audible after going out of sight. Noise was rough and "like noise of a hoover finishing up". Time: 11.55 – 12.00 noon. (uncertain)

Witnesses No. 4 and 4(a). He and brother saw an aeroplane with right outer half of wing very red, as if on fire. The aeroplane was travelling in south-easterly direction, over Baginbun. Time about 11.45 a.m. (but uncertain).

Witness No. 5. Heard noise as if from between Slade village and Conningbeg Lighthouse. Noise was normal and faded away normally. 3 or 4 minutes later heard noise, much louder, and seeming from between Slade and Saltees. Noise lasted about 2 minutes and sounded overhead. Noise cut out suddenly. Did not look up. Time 11.40 – 11.45 a.m. to say 11.50 a.m.

Witness No. 6 saw bright object in water SW of Greater Saltee, about 3 miles. The object was aluminium in colour. Left portion was oval, centre portion was submerged. Right portion was uneven, but protrusion was more pronounced. It appeared to be about 80' long. Time 2.45p.m. Local Summer time to 3.20 p.m. Local Summer Time.

Witness No. 7 saw an object in the sea, west of Great Saltee Island, ¼ distance between Grt. Saltee and Conningbeg, but further out to sea. Object was silver colour. Looked about 8' square. Time 1.45 p.m. to 3.30. Ship came from Tuskar and passed a mile inside the object and carried on.

Witnesses Nos. 8 to 12. At 12.00 hrs. approximately heard a noise like thunder a short and sharp roll. One witness described it as a double clap.

Witnesses Nos. 13 – 14 heard a noise like thunder (Bang) at 12.00 hrs. approximately. They were sitting in the kitchen of their homes, one witness ran out and observed a darkish cloud low in the sky between Tuskar and the Barrels.

Witness No. 15. This witness was feeding cattle near the Rosslare Golf Pavilion. At 12.00 hrs. he heard a noise which he described as a loud "whoosh" from Tuskar direction.

Witness No. 16 was walking on strand at 12.00 hrs. approximately he heard a noise which he described "like a jet coming out of the clouds". A portion of Viscount elevator spring tab was found washed up on the beach in this location in October, 1968.

Witnesses Nos. 17 and 18. No. 17 at Bing, near Greenore Point. Saw a column of water on left side (north) of Tuskar "near where the Irish Lights vessel anchors when servicing Tuskar". Column went up as high as Tuskar Rock itself. Saw two ships "going round the back of the Tuskar afterwards", neither deviated from its track. Heard a loud noise like water running off rocks. No. 18 heard the noise, but was not in a position to see anything.

Witness No. 19. Spanish sailor on M.V. Metric thought he saw an aeroplane "at altitude of 3 metres", falling on left wing. Saw some water thrown into the air, 2-3 miles from ship and in line with Tuskar (Tuskar abeam about noon).

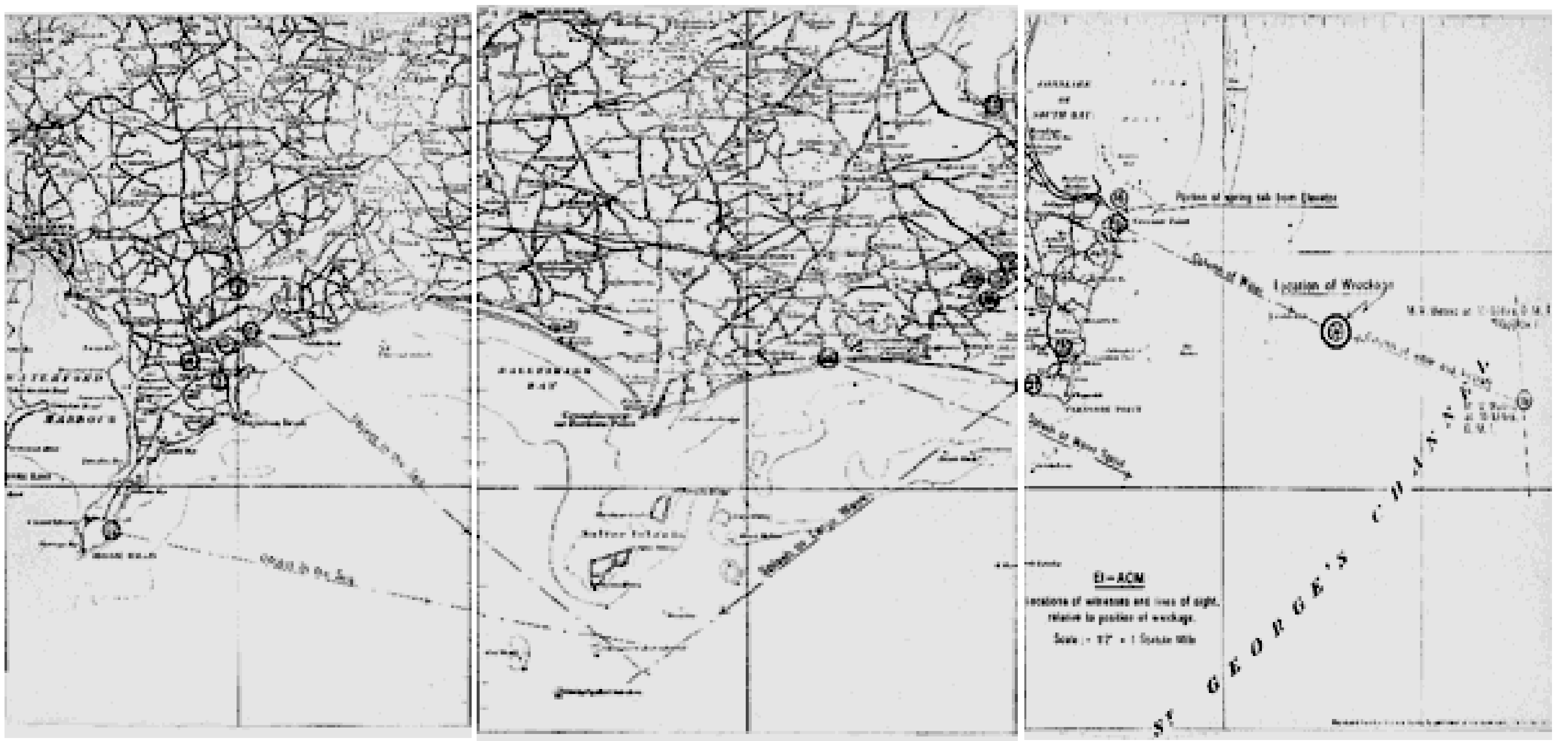
(At 12.10 Metric was on a course 108° Tuskar 7 miles)

Witness No. 20 on a line between the Black Rock and Carnsore Point, and about nine (9) miles out, saw a "Mushroom of water". Time: mid-day approx.

Witness No. 21 saw a very large wave on a line over Black Rock in the direction of the Saltees. The time was 12.00 hrs. approximately.

Witness Nos. 22 – 26 heard noise at 12.00 hrs. approximately, described as like a sharp roll of thunder.

Map showing the general area of the accident and locations of witnesses to whom reference is made in the Report.

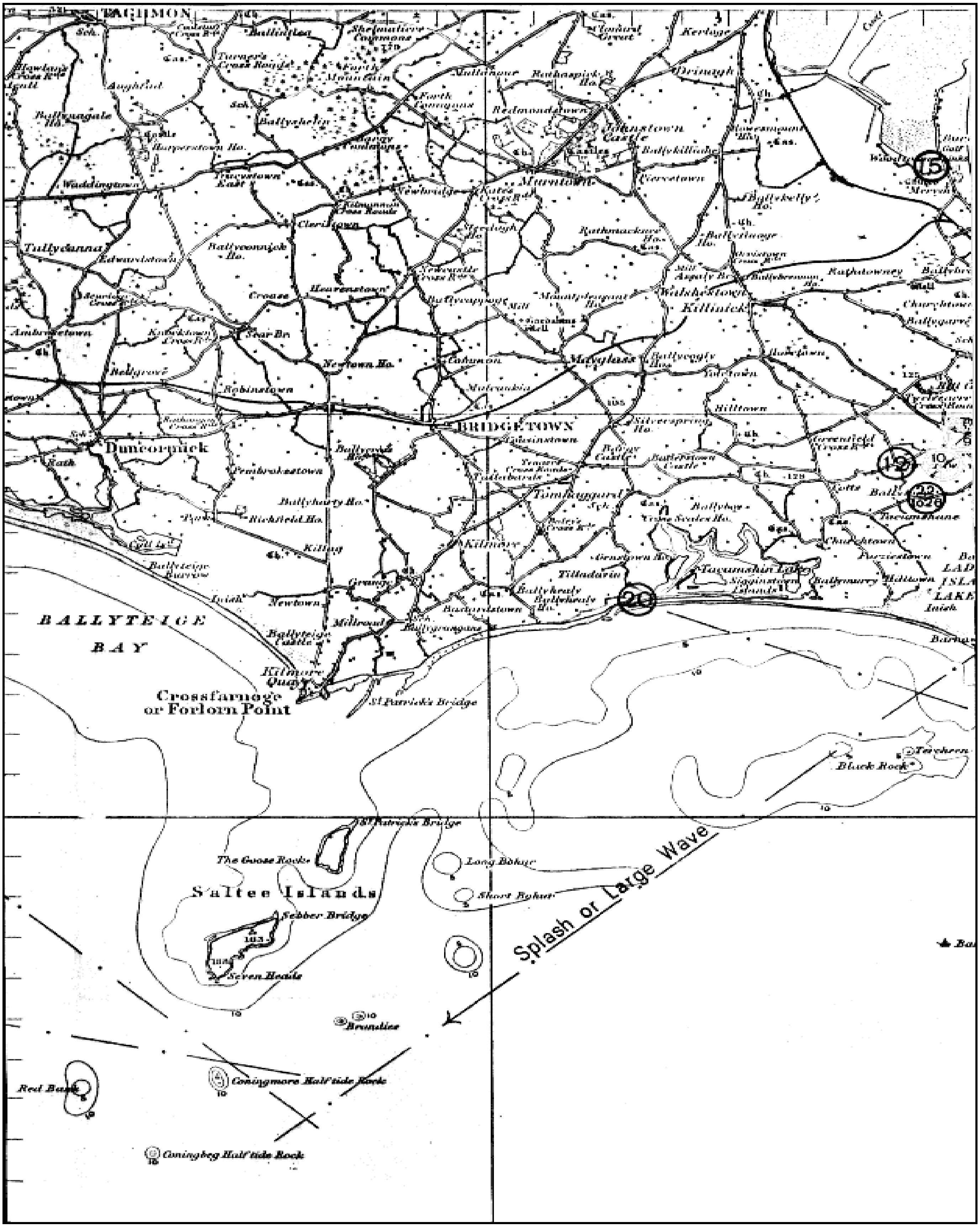


Section A

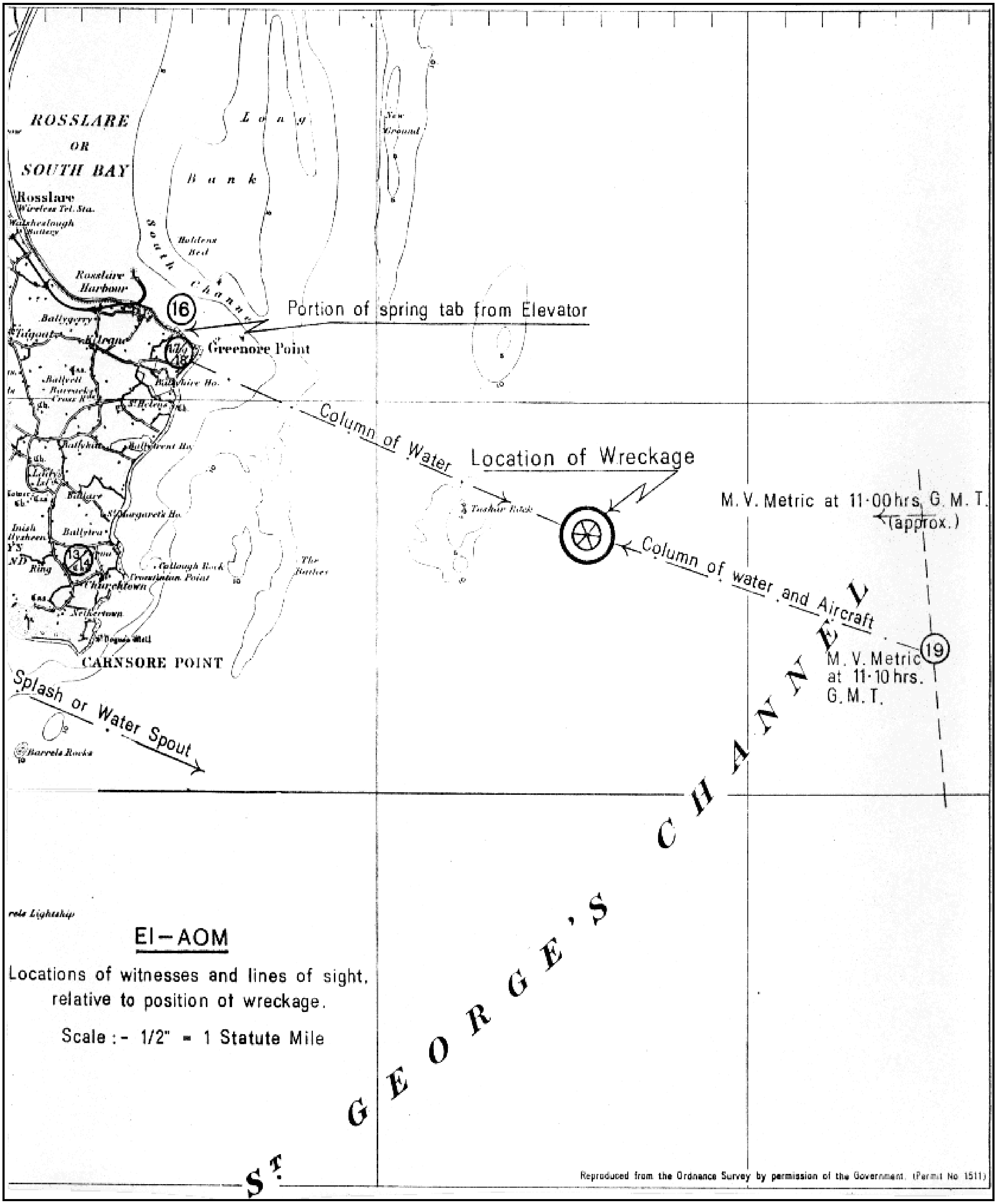
Section B

Section C

Section A of Main Map



Section B of Main Map

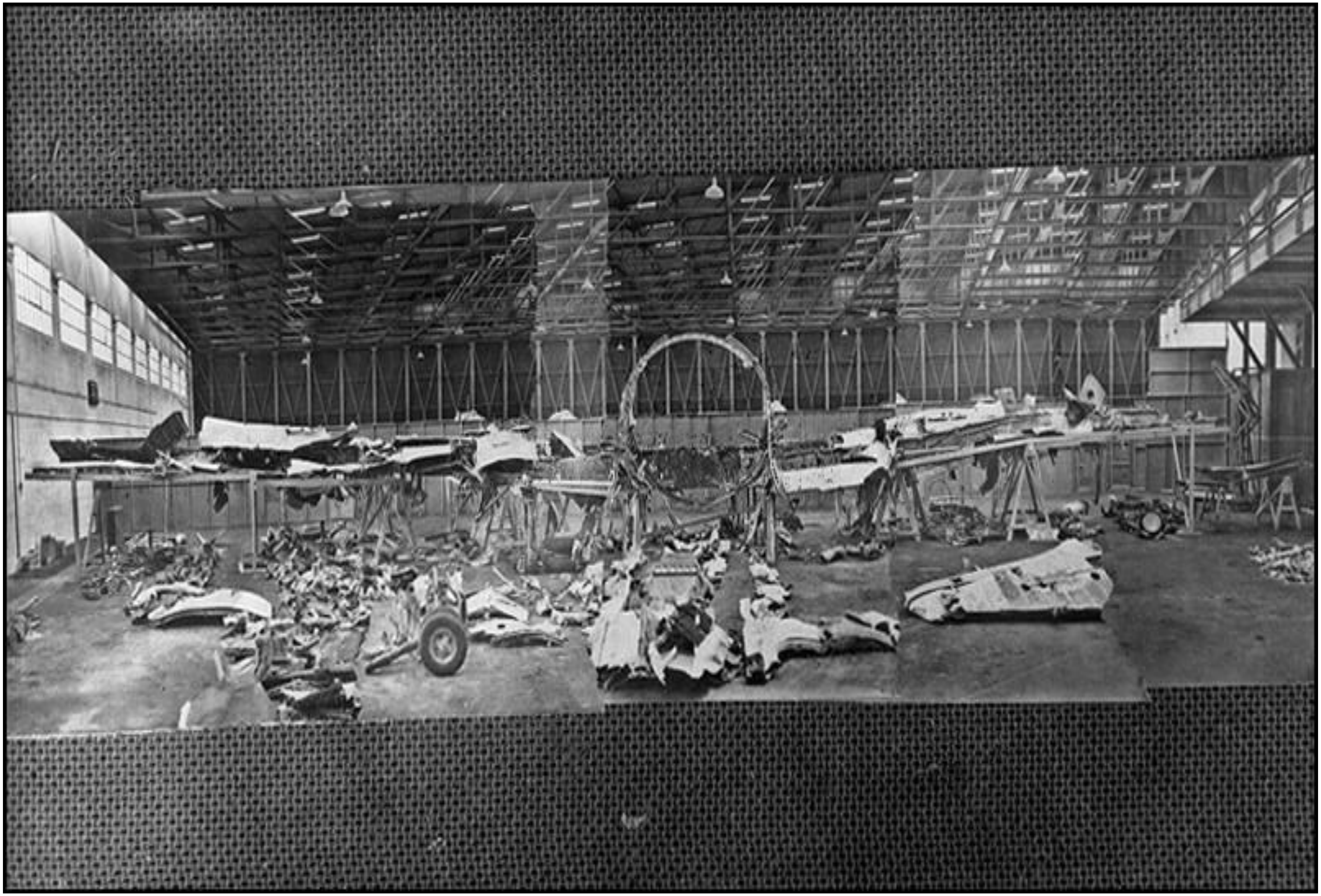


Section C of Main Map

Appendices Photos

1. Photo1
2. Photo2
3. Photo3
4. Photo4
5. Photo5
6. Photo6

Appendices Photo 1



Appendices Photo 2

Appendices Photo 3

Appendices Photo 4

Appendices Photo 5

Appendices Photo 6